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CONSERVATION OF WORLD RESOURCES

THE Materials Policy Commission, established by President Truman on January 22, 1951, to make a long-range study of the materials problem of the United States, having regard to the needs and resources of friendly nations, was also charged with assisting the formulation of materials policy. The Commission was assisted by a comprehensive staff, as well as by a panel of the National Research Council and by numerous industrial firms, universities and other bodies. The work of the Commission has now been made available in a comprehensive report* running to five volumes, of which the first, entitled "Foundations for Growth and Security", embodies the bulk of the findings and recommendations, constituting a summary and broad analysis of the whole problem. With the fourth volume, "The Promise of Technology", it is the part of the report of most interest to the scientific worker, though the technologist will also be concerned with the second and third volumes, dealing with the outlook for key commodities and energy sources, respectively. The fifth volume presents a few of the basic studies prepared to assist the Commission.

The report of this Commission, known from its chairman, Mr. W. S. Paley, as the Paley Commission, was sent to Congress on July 1, 1951, and the National Security Resources Board was asked by President Truman to study the Commission's seventy-eight specific recommendations. A special body was set up by that Board to submit suggestions for implementing those recommendations as well as to assist in continuing the review of materials and energy policies and programmes. Originally the proposals of the National Security Resources Board were to be forthcoming within sixty days; but this task proved too great for the original time limit. Nevertheless, the report of the Materials Policy Commission seems likely to result in definite action by the United States Government.

One of the most interesting features of the report is, however, the way it endorses an opinion expressed earlier in the year in "Facts and Figures for the Chemical Process Industries" by E. W. Pehrson, of the United States Bureau of Mines, that, from a miners' point of view, the United States are a 'have-not' nation in several indispensable minerals, and that for some of these the United States cannot hope to improve their position significantly through increased domestic output. Pehrson, in this article, listed thirty-eight important natural raw materials, and showed that in only nine of these are the United States self-sufficient, and for twelve they produce only ten per cent or less of their needs. The Paley Commission, in the first volume of its report, lists the production and reserves of twenty-two key materials in the free world, on all of which the United States are already substantially reliant or likely to become

* Resources for Freedom. (A Report to the President by the President's Materials Policy Commission.) Vol. 1: Foundations for Growth and Security. Pp. viii+184. 1.25 dollars. Vol. 4: The Promise of Technology. Pp. x+228. 1.75 dollars. (Washington, D.C.: Government Printing Office, 1952.)

more reliant. Furthermore, with but 6·3 per cent of the world's population, the United States use 45 per cent of the world's minerals and are responsible for 50 per cent of the world's industrial output.

During the first fifty years of this century, the population of the United States has doubled, while the national output increased five times. While the consumption of agricultural products of all kinds, including food, increased two and a quarter times, the consumption of minerals, including fuels, increased sixfold. By 1950, in comparison with 1900, the output of coal had increased two and a half times, of copper three times, of iron ore three and a half times, of zinc four times, of natural gas twenty-sixfold, and of crude oil thirtyfold. This trend is expected to continue. It is estimated that by 1975 the demand for minerals as a whole will be twice as heavy as in 1950, though it is difficult to forecast the increased demand for any particular material.

To readers of the report outside the United States the most interesting feature, however, in its analysis of the materials situation is not the realization by the United States of the worsening relationship between their requirements and their means of satisfying them, but rather the outlook revealed by the Commission. There is official recognition that supplies are not inexhaustible, that even the United States must learn to be less wasteful of their natural resources of minerals, great as they are, and must accept the necessity of re-using the products of those resources many times over, and improve their techniques for the discovery and development of mineral resources. The Paley Commission points out that by making fuller use of known resources either by the avoidance of wastes, the exploitation of materials of lower grade or quality, or the utilization of waste products, the supplies of domestic materials can be expanded. This is largely a matter of expanding technology, though new physical knowledge may also be required.

Both factors contribute to the improvement which could result by shifting from the use of scarce to more abundant materials, or the more economical use of materials which comes when they are used under conditions having closer regard alike to their intrinsic properties and to the purpose to be served. Whatever advantage can be drawn from the synthesis of new materials to relieve existing shortages, the recovery of valuable materials from waste products or scrap, the prevention of corrosion and the reduction of losses in storage or transport depend on technological skill and scientific knowledge. Furthermore, they may also determine the capacity of the United States for dealing with what the Commission describes as the real threat in their materials problem.

This threat does not relate to absolute shortages but is due to the insidiously rising real costs—the hours of human work and amounts of capital required to bring a pound of industrial material or a unit of energy into useful form. During most of the twentieth century these real costs of materials have been declining, and this decline has assisted in raising standards of living in the United States. The Paley Commission believes that this trend has now been retarded, sometimes stopped and even reversed.

The central challenge of the materials problem in the United States is accordingly to meet expanding demands with expanding supplies, while averting a rise in real costs per unit. This question of costs is manifestly likely to be more difficult to overcome than in the past. Only in chemicals have real costs apparently declined faster in the past decade than in the previous four; and whereas wholesale prices of commodities in general advanced about 105 per cent between 1940 and 1950, that of zinc rose 119 per cent, petroleum 149 per cent, farm products 152 per cent, lead 157 per cent and lumber 218 per cent. Other materials, including aluminium, iron ore, nickel, sulphur and copper, rose less than the general average. But the rate of technological progress, which could help to counteract this situation, depends largely on the supply of scientifically trained personnel and the expansion of the fundamental scientific knowledge upon which technology is based; here the Paley Commission states that available evidence shows that the prospective flow of scientific men and engineers from the universities is alarmingly below apparent needs.

The Commission accepts the view that the United States have been less assiduous in increasing the store of fundamental knowledge than in applying such knowledge in industry, and that fundamental research in the United States should be more in balance with the expenditure of effort on applied research and development. It does not believe, however, that the United States Government has a philosophy of research commensurate with its present responsibilities for the allocation of financial support. At no point in the government organization can a comprehensive picture be obtained of the pattern of technological activity financed by the Government or an appraisal of that pattern.

In general terms, the Commission formulates six main tasks for technology: the fostering of new techniques for discovery; the utilization of new materials; the broader application of the principle of re-cycling; the handling of low concentrations of useful materials; the development and more economic use of renewable resources, such as solar energy; and the use of more-abundant materials to lessen or eliminate the use of a scarce material. These are dealt with in a subsequent chapter in the first volume, but detailed discussion is reserved for the fourth volume, in which specific problems are indicated. Here we can only consider the Commission's further judgment of the United States resources of trained man-power and their direction, which are examined in the chapter on "Government and Materials Research".

The United States are estimated to have roughly 625,000 scientific workers and engineers, of whom some 76,000 scientists and 59,000 engineers are engaged in research—nearly 60 per cent in industrial laboratories, about 20 per cent in government laboratories and 20 per cent in educational institutions, scientific foundations, and the like. As already indicated, the Commission concurs in the view that there is likely to be an acute shortage of technical man-power in the immediate future, and it recom-

mends that both industry and the government should give the maximum support to programmes for advanced training consistent with the number of young scientific workers willing and able to continue their work. It also recommends that the appropriation of the National Science Foundation should be increased to the limit of 15 million dollars which Congress inserted into its basic Act, and that Congress should re-examine the bases upon which it set this limit so low.

The most pressing need, however, is for better co-ordination. The Commission believes that establishment of an active co-ordinating body is essential for shaping and executing a comprehensive, effective national policy of materials research. Such an organization would estimate and appraise the impact of technology and other forces upon supply. It would, for example, revise continually estimates of reserves in the light of new discoveries and the development of new uses and methods; estimate annually requirements of supplies at least ten years into the future on the basis of scientific and technological developments, as well as data on domestic production and consumption, and imports and exports; report potential shortages of important materials far enough in advance to permit corrective action; and maintain an up-to-date list of the materials research and development projects that should be undertaken. For such projects that cannot normally be assumed by industry, it would consult with the appropriate advisory bodies and, if necessary, bring the problem before the President or Congress. Such an organization would necessarily occupy a high place in the structure of the Federal Government and maintain close relations with the National Science Foundation and many other government agencies as well as with industry. The Commission recommends that the National Security Resources Board should be directed to provide such a co-ordinating service.

Whatever action may be taken on the Paley Commission's report in the United States cannot affect its value as a record of a reasonable appraisal of the situation over the next twenty-five years. Moreover, although in the lineage of Vannevar Bush's "Science, the Endless Frontier" and the Steelman report on "Science and Public Policy", it does more than record the view that the United States should be increasingly concerned with the conservation of resources: it asserts that the problem is one for the free world as a whole, and in which international co-operation is indispensable. The major premise of the report is, in fact, that the overall objective of a national materials policy for the United States should be to ensure an adequate and dependable flow of materials at the lowest cost consistent with national security and with the welfare of friendly nations. The Commission recommends that increasing emphasis be given under the United States programmes of technical assistance to under-developed areas for geological survey, preliminary exploration, and advice on mining technology. Support for these programmes should be increased to as much as four million dollars a year; but the extension of technical assistance in these fields should be accompanied by assurances to the United States that the recipient country will promote conditions favourable to developing such resources as may be discovered.

This objective inquiry has thus summoned the United States to conserve natural resources and co-ordinate them along with those of the other free nations to the ends of common growth, common safety and common welfare, almost simultaneously with Prof. A. V. Hill's reference to this question of world resources and world population in his presidential address to the British Association. Prof. Hill emphasized the challenge of the present situation to the responsible use of knowledge and the combined resources of science, humanity and statesmanship. The Paley Commission affirms its belief in the principle of growth and in private enterprise as the most effective means of performing industrial tasks in the United States; but it believes also that the destinies of the United States are inextricably bound up with those of the free world. There is much technical detail of wide interest to be found in these reports, but there is nothing more encouraging or more widely welcome than the evidence they contain of this spirit of co-operation and of readiness to approach the common problem of raising the standards of living of the free world as a whole, responsibly and imaginatively, with all the resources which science and technology can put at the disposal of statesmanship.

THE SOLAR SYSTEM

The Origin of the Earth

By Prof. W. M. Smart. Pp. viii+239+8 plates. (Cambridge: At the University Press, 1951.) 12*s.* 6*d.* net.

PROF. W. M. SMART has written this book for the general educated reader, who, in the first part, will find an admirably descriptive account of the solar system, which is complete in itself. The material is presented so as to lead up to the conclusion that the uniformities of orbital and rotational motions in the solar system are so pronounced as to make it very probable that the whole system must have come into being as the result of a single cosmical process. There are exceptions to these uniformities, the most striking being the existence of retrograde satellites. But there is a rational explanation; it is significant that the retrograde satellites are mainly to be found at the outermost fringes of the planetary systems concerned. To quote Prof. Smart: "There is perhaps a little justification for the suggestion that the satellites not conforming to the majority rule may have been originally minor planets which, through the interplay of planetary and other attractions, have been captured by the parent planets".

Having decided that the solar system originated as the result of a single cosmical process, the next question is: When did this happen? The second part of the book is devoted to the answer to this question, and an obvious starting-point is the age of the earth. Prof. Smart recalls the nineteenth-century controversy between Kelvin and the geologists, and he then gives an excellent résumé of the main facts of radioactive and nuclear phenomena, leading up to a clear account of the radioactive method of

determining the age of the earth's crust, which is tied down to something between two and four thousand million years. He then passes on to an account of the astronomical evidence which leads to estimates of the ages of the moon, sun and universe. The evidence from these phenomena of the expansion of the universe is outlined, leading to the conclusion that "we are left with a time scale of a few thousand million years within which the universe has reached its present development from an initial state of high concentration. The evidence from the lengthening of the day as a consequence of tidal friction leads to the conclusion that about 4,000 million years ago the moon's centre was but 8,000 miles from the earth's centre, and that then the period of orbital revolution of the moon was equal to the rotational period of the earth, both being about 4 hours". The further suggestion seems to be unavoidable that the moon had then just been formed from the earth, from which it follows that the age of the moon is about 4,000 million years at most.

As regards the age of the sun, Prof. Smart indicates how current ideas of the source of stellar energy lead to the conclusion that the sun's age "must then be much less than 8,000 million years". I feel that in this part of his book Prof. Smart may have produced an impression in the general reader's mind which is rather too dogmatic. He gives an admirable account of the known thermo-nuclear reactions which may have been effective in the life-history of the sun. But I think he could have made it clearer that our knowledge of these processes is probably incomplete and that other nuclear processes, of which at present we are ignorant, may have been effective. Until the method of synthesis of the more complex nuclei is understood, it is probably imprudent to be dogmatic. But having said this much, I hasten to add that the general reader will find a fascinating and well-written account of those thermo-nuclear reactions which have been studied and are now well understood.

There remains the question of the exact mechanism of the cosmical process whereby the solar system was formed. The answer really is that we do not know, and in the third part of the book all that Prof. Smart can do is to give an account of the various theories that have been advanced. He records the conclusion that "the scientific search for an answer to our final question has thus failed, up to date, to reach a solution agreeable to astronomers other than those perhaps who individually are concerned with the formation of a particular theory". A very sound and salutary conclusion!

The high standard of presentation is only what one expects from the Cambridge University Press. The book is excellently illustrated.

W. M. H. Greaves

PREHISTORY OF UGANDA

The Pleistocene Geology and Prehistory of Uganda Part 2: Prehistory. By Dr. C. van Riet Lowe. (Geological Survey of Uganda, Memoir No. 6.) Pp. x+113+54 plates. (Entebbe: Geological Survey of Uganda, 1952.)

PROF. C. VAN RIET LOWE, of the University of the Witwatersrand, Johannesburg, has won a great reputation among archæologists for the work he has accomplished on the prehistory of South Africa. What then could be more fortunate than the collaboration of a man who knows as much as he does of the prehistory of the subcontinent with a colleague like Mr. E. J. Wayland, the director of the Geological Survey of Uganda—a man whose knowledge of his subject is unrivalled and who shares Prof. Lowe's love for prehistory! Part 1 of Memoir No. 6 of the Geological Survey of Uganda has yet to appear, and in it Mr. Wayland will deal with the Pleistocene geology of the Uganda area; it is to be hoped that he will not delay too long in publishing the fruits of his researches. Meanwhile, and happily, Part 2 ("Prehistory") of the Memoir has appeared, the result of some months of field- and museum-work in Uganda carried out in 1939 by Prof. Lowe, who worked at Mr. Wayland's sites with him and collaborated very closely. The work is exactly what one could have hoped for—a straightforward and lucid account of the Stone Age cultures of Uganda based on the geological and archæological investigations of Mr. Wayland.

It is perhaps to be regretted that the author was unable, as he states, to examine an earlier work on the area—Mr. T. P. O'Brien's "The Prehistory of the Uganda Protectorate"—while he was working in the country. One questions whether a most understandable desire to avoid entering the lists of East African prehistoric controversialists really does excuse the ignoring of this book; for though O'Brien was not a geologist, he did have geological advice, including much kind help from Mr. Wayland, and had some experience in typology—and he did produce an impressive volume. It was always clear that his presentation of the story was open to criticism; in this case, for example, it would seem that Prof. Lowe does not agree with all his conclusions, such as the dating of the Kafuan culture; but it would have been a great help to prehistorians who have not worked in Uganda to have had the criticisms of the work of Prof. Lowe's predecessor from the pen of one who does know the country.

The memoir opens with a historical review—necessarily mainly an account of Wayland's connexion with Uganda. While not going into details, the geological setting is here given and, a little later, there is a diagrammatic section of the Kagera river valley near Nsongezi showing terraces and the 'M', 'N' and 'O' horizons. There are chapters on the various cultures, starting with the Kafuan and reviewing the African Chellean, the African Acheulean, the Sangoan, and the Upper and Epi-palæolithic cultures and concluding with the Neolithic. In dealing with the Magosian culture, in the publication of which I was proud to be associated with Mr. Wayland in 1932, Prof. Lowe regrets that as all the material was sent to Cambridge he can only summarize the descriptions given in the paper referred to. There are thus no illustrations of the Magosian industry in this book—a notable lack in such a definitive work on the prehistory of the country. Yet reproduction of the original drawings or a choice re-drawing of the specimens could easily have been arranged. A brief but excellent summary and conclusions, with a useful table of climatic and geological correlations and, later, a bibliography, complete the text of 113 pages. Commenting on the surprising absence of any expression of the 'Capsio-Aurignacian complex' in Uganda, the author suggests that this may have been due to the lack of any fine-grained material such as flint, obsidian or indurated shale suitable for the manufacture of blade-and-burin industries. I have always felt that early man was very much at the

mercy of physical Nature and feel sure that, as prehistorians discussing distribution maps, we often pay too little attention to this kind of circumstance. Lastly come fifty-four full quarto pages of illustrations of stone industries. These are well-chosen and very well drawn, many of them from the gifted pen of Mrs. Leakey—and it is no easy matter to interpret specimens of fairly crude industries when they are made from coarse-grained materials lacking the clearly defined flake intersections of flint and similar materials.

Altogether Prof. van Riet Lowe is to be heartily congratulated on having accomplished so much in his visits to Uganda (none of them very long), on having written a clear and much-needed account of the industries of the country founded on sound geological premises, and on having made available for study in the illustrations a large number of stone implements of various ages and cultures. M. C. BURKITT

'MAXWELL'S SPOT' IN COLOUR VISION

New Means of Studying Color Blindness and Normal Foveal Color Vision

With some Results and their Genetical Implications. By G. L. Walls and R. W. Mathews. (University of California Publications in Psychology, Vol. 7, No. 1.) Pp. iv+172. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1952.) 2.50 dollars.

THE storms that periodically affect the world of colour show few signs of abating, and a fresh disturbance from the west, indeed from as far west as California, is heralded by this monograph. Dr. G. L. Walls is already well known as the author of "The Vertebrate Eye and its Adaptive Radiation", but the present work is in no sense a staid text-book. On the contrary, it is a trenchant criticism of many orthodox views and many orthodox workers, and perhaps we should be grateful that at least two British men of science in this field, Dr. W. S. Stiles and Dr. F. H. G. Pitt, emerge relatively unscathed.

For once, however, it is not the three-component theory of colour vision that is under attack. At the outset, the authors make it clear that they are staunch supporters of this theory, and, while their main theme concerns defective colour vision, it is their views on the yellow macular pigment that will probably create the greatest interest. A yellow pigment is believed by many authorities on vision to occupy the central macular area of the retina, and variations in its density are commonly regarded as a major cause of individual differences of colour perception and colour matching. The present authors do not actually deny the existence of the pigment, but they do deny that it plays the important part that is frequently attributed to it.

A subjective demonstration of the macula is obtained when a uniform area of light such as the sky is viewed through a filter which transmits mainly at the far red and far violet ends of the spectrum. A diffusely defined reddish area is seen projected against the sky, and, as the gaze is directed from one part of the sky to another, so the spot follows the direction of view. It quickly disappears owing to local adaptation of the retina, but is restored to view if the filter is momentarily removed and then replaced. Sometimes the spot can be seen, without the aid of a filter, projected on a material dyed with a dichroic dye, although such dyes are normally avoided both because of their apparent spottiness and their marked change of colour with quality of the lighting.

James Clerk Maxwell studied this spot in some detail, and it is often referred to as 'Maxwell's spot'. An obvious and commonly held explanation was absorption of the blue radiation by the yellow macular pigment, and it is this explanation that Walls and Mathews flatly reject. They have been to considerable trouble to discover a filter which shows the effect as clearly as possible, and, with the aid of an experimental Wratten filter, detailed structure within the spot can be observed. The structure varies considerably from observer to observer and even between the right and left eyes of a given observer, but most often a central red spot subtending about $\frac{1}{2}°$ is seen, and then an annular clearing of the same colour as the background, surrounded by a further red zone the diameter of which is some 3–4°. Occasionally, a tiny pip of the colour of the background is located at the centre of the central spot, an effect I can see in my left eye using Walls's filter, but not in the right.

Walls and Mathews point out with some logic that a yellow pigment impregnated in the retinal tissue could scarcely account for the structure of Maxwell's spot, since the retina is thinnest in the central $\frac{1}{2}°$ of the fovea in just the area where the blue absorption should be greatest. They therefore attribute the phenomenon to variations in distribution of the retinal colour receptors, and they point in particular to the recent experiments in foveal tritanopia (which they call tetartanopia) as evidence that the blue receptors are missing in the foveal centre.

A number of other arguments are assembled to demolish the macular hypothesis, including the discovery that one group of colour-defectives, the deuteranopes, are unable to see the Maxwell spot. The latter half of the monograph is, in fact, mainly devoted to a description of the spots seen by colour-defectives and to a discussion of the observation as a colour vision test.

There is much here that deserves detailed study, and the analysis is undoubtedly made more difficult by the fact that in some respects both a yellow pigment and absence of blue receptors could produce rather similar effects. It does no harm for orthodoxy to be subject to the fierce criticism that we have here, but not all the arguments are equally valid. Many people would probably give greater weight to the histological arguments if reference had been made to Polyak's work. Then the authors criticize the use of data derived by calculation from the C.I.E. colorimetric system in place of direct experimental observations, yet their own neutral-point determinations were calculated on the C.I.E. chromaticity chart.

Perhaps the main misinterpretation, however, is in attributing colour-matching differences to differences in receptor distribution. Two different physical stimuli that have the same colour would remain a match however much the proportions of red to green to blue receptors were changed in the area of the retina viewing the two lights. The appearance of the lights would change, but they would still match. On the other hand, if the spectral sensitivities of the receptors were altered, or if a colour [illegible] were introduced in the two beams, the match would break down.

Actually, colour matches differ from one observer to another very much as if a yellow filter of differing density had been introduced, hence the argument for the yellow macular pigment.

Yet difficulties do remain, and we can still be grateful to the authors of this monograph for their ruthless exposure of some of the fallacies of the pigmentary theory of Maxwell's spot without necessarily accepting all their arguments and conclusions.

W. D. Wright

TEXT-BOOK OF PLANT PHYSIOLOGY

Principles of Plant Physiology

By James Bonner and Arthur W. Galston. (A Series of Biology Texts.) Pp. x+499. (San Francisco: W. H. Freeman and Co.; London: Bailey Bros. and Swinfen, Ltd., 1952.) 5.50 dollars; 47*s*.

DESPITE (or perhaps because of) the rapid progress during the past twenty years in the elucidation of plant physiology, text-books in this field of natural knowledge have remained notoriously few and far between. The appearance of a new one is thus an event of unusual interest.

This new volume, originating chiefly from the California Institute of Technology, is distinguished especially by the excellence of its treatment of the more biochemical aspects of the activities of the plant, and there are admirable chapters on photosynthesis, carbohydrate metabolism, respiration, nitrogen metabolism and enzyme action. The capacity and enthusiasm of the authors are, however, by no means exhausted by their labours on nutrition and metabolism, as is shown when they proceed, in the last third of the book, to give a stimulating and authoritative treatment of growth and development, in which the plant hormones, tissue culture and photoperiodism receive especial attention.

In general the information provided is thoroughly up to date, and, though references are not cited in the text, a short list of sources is appended to each chapter. The book as a whole is written at a level approximating to that of a general degree course in botany, but in biochemical and some other aspects the standard of treatment is nearer to that of a special course. Omissions that may be noted include a failure to attempt an adequate explanation of root pressure, or to mention frequently observed phenomena such as guttation, nastic movements, haptotropism or nutation. Minor objection could be taken to a preliminary statement on p. 11, which might be interpreted to mean that the oxygen of photosynthesis originates from carbon dioxide—the correct position on this is of course clearly indicated later in the chapter—and also to a slight uncertainty in the text as to whether or not the authors intend photosynthesis to be reckoned as a part of the metabolism of the plant.

In contrast with most other text-books on plant physiology, this one is copiously illustrated by means of drawings, diagrams, cartoons and graphs, to a total of 218. Many of these are excellent and some decidedly novel, such as that in which the familiar Askenasy apparatus is depicted as seen obliquely from above. But a few of the illustrations fall below the high standard set by the text. Fig. 11–9, purporting to illustrate the legume root nodule, is decidedly crude. The diagrams referring to plasmolysis fail to accord with the text in that they show no overall shrinkage in the size of the cell. The seedlings portrayed in Fig. 14–4 and stated to be "beans" seem more likely to be those of a cucurbit.

These minor criticisms do not detract significantly from the assessment of this new work as a notable achievement. It is written in a lucid and interesting style, and is printed in a large, easily read type. A first reading has yielded only a single misprint. In so far as the rather high price permits of it, this text-book should be in the hands of all students reading for a general or special degree in botany.

G. Bond

PLANT RESPIRATION

Respiration in Plants

By Prof. Walter Stiles and Prof. William Leach. (Methuen's Monographs on Biological Subjects.) Pp. vii+172. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1952.) 10*s*. 6*d*. net.

THIS little book was first published in 1932 and no monograph of plant respiration has appeared during the succeeding twenty years. It has therefore carried a heavier burden than perhaps even its authors anticipated, and, meanwhile, much has happened to the subject it describes. The foundations of the study of plant respiration were firmly laid about the start of the century, so it would be too much to say that the progress of the past twenty years has been revolutionary; but it has advanced to new levels and depends on different tools.

In preparing the third edition it has not been found necessary to alter the plan of the book, or to rewrite the first three of its four chapters, though a number of important additions have been introduced. The pages of text have been increased from 108 to 142, and 21 of the new pages are in the last chapter, which has been extensively rewritten. This is a fair reflexion of the present emphasis on the study of intermediate stages and chemical mechanisms.

The description of so complex a branch of metabolism within such narrow limits necessarily assumes a great deal of background knowledge on the part of the reader—perhaps about the amount commonly assumed in advanced lectures. It also necessitates the making of statements—such as that the end-products of aerobic respiration are the same as those of hexose combustion—without much evidence or discussion. It is presumably for the same reasons that one might be led to suppose that virtually the whole energy turnover of anaerobic respiration may be usefully transferred. To keep such difficulties within bounds, the authors have limited their choice of topics, and have in general succeeded in giving good grounds for the opinions they have adopted. While it would be difficult always to agree with them, it is good to note the caution with which they approach controversial matters. It is refreshing to find in so brief an account more than one idea of the fate of pyruvic acid and a reluctance merely to assume the identity of anaerobic respiration and alcoholic fermentation.

The changes noted in this new edition are all for the good; and, even when setting the first edition within the framework of its time, the new edition seems a better book and likely to be even more useful to students than its predecessor.

W. O. James

'KRILIUM' AND SYNTHETIC SOIL CONDITIONERS

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THE announcement of a synthetic soil conditioner, for the improvement of soil structure on a wide scale, was first made at a meeting of the American Association for the Advancement of Science held in Philadelphia on December 29, 1951, where a symposium on the improvement of soil structure by the application of organic matter took place. The papers read at this symposium have been published[1], and I have given a summary of them[2]. The present article is intended to give some account of the development and properties of soil conditioners.

Soil Organic Matter and Soil Structure

The organic matter of soil plays an essential part in securing in soil the structure that is required for high fertility. The maintenance of the supply of organic matter to arable soils is, indeed, a matter of the greatest economic importance, for productive capacity is largely dependent upon it. It is a well-known fact that an arable soil regularly supplied with farmyard manure has an improved and more stable structure than the same soil that has not received organic additives. A more friable crumb structure resistant to disintegration by water is produced.

The organic matter of soil is primarily derived from the decomposition products of plants and from the products of autolysis of the immense numbers of micro-organisms which develop at the expense of substances of plant origin. A dynamic equilibrium exists in the soil between the numbers of bacteria, protozoa, yeasts and fungi, etc., that inhabit the soil and the organic matter being continually supplied by the decaying animal and vegetable tissues. Soil, therefore, normally contains a wide range of substances commonly classed as metabolites of animal and plant tissues. The speeds of change of these substances may be very great, the rates depending on the temperature, hydrogen ion concentration, aeration, availability of water and mineral content of the soil. A number of substances, derived from animal, plant or microbiological life, are, however, relatively resistant to breakdown, and these substances make up for the most part what is commonly known as organic matter. Such substances have the physical and chemical properties which together help to determine the structure and to influence the fertility of a soil.

Among the most characteristic of the products making up the soil organic matter is the black colloidal material having high hydrophilic power known as humus. This is a complex mixture of substances which was once thought to be formed solely from the cellulose in soil but which is, in fact, a natural system varying in composition and consisting largely of various derivatives of lignins, proteins and celluloses. This organic matter greatly influences the structure of a soil, and therefore the air–water relationships upon which the fertility of a soil depends.

The structure of a soil refers to the grouping or clustering of soil particles into aggregates or crumbs that at once influence water-movement, aeration and heat transfer. The granules that make up a soil of good structure may have a tremendous internal surface like that of a highly porous sponge, and it is in this large surface area that many of the biochemical and chemical changes take place that so markedly affect fertility. It is here where develop micro-organisms which convert organic nitrogenous compounds into the nitrate required by the plant roots, where metallic ions required by the plant are held by the soil in a base-exchangeable, or dissociable, form, where oxygen is dissolved and carbon dioxide is generated influencing local acidity and the metabolism of the plant root.

Aggregating substances are found uniformly distributed in soil crumbs. These consist[3] of organic compounds resulting from the decomposition of fresh organic matter and of a group of substances, including oxides of iron and aluminium, fats, waxes and resins, which are less efficient than the former as soil aggregators. It is well known that bacterial slimes and fungal mycelia play an important part in soil aggregation and the resistance of soils to erosion.

It is now known that among humus constituents are the polyuronides, substances related to the sugars and existing in a polymerized form. Forsyth[4] has, for example, isolated from soil a polysaccharide fraction containing uronic acid units. These are widely distributed in plants, composts and soils. The quantity of polyuronide present in soil varies with the type of soil[5], and there is evidence that the more fertile the soil the greater is the quantity of polyuronide present. Polyuronides include such well-known substances as pectic acid, alginic acid and a variety of bacterial polysaccharides. They compose the plant gums that are found in soils containing decaying vegetable matter. Bacterial polysaccharides such as the levans and dextrans also have marked aggregating effects on soils[6,7].

Alginic Acid and Soil Structure

The large effect of a polyuronic acid, such as alginic acid, in increasing the water-holding power and crumb-stability of a soil was first shown by Quastel and Webley in 1947[8] in work carried out during 1941–45 in the Agricultural Research Council Unit of Soil Metabolism at the Rothamsted Experimental Station, Harpenden. These investigators used a manometric method of assessing the availability of oxygen to living cells, such as those provided by micro-organisms and plant roots, present in soils. The technique made it possible to investigate rapidly the immediate effects of the addition of various forms of organic matter on water-holding power and crumb-stability of soil. It was speedily found that the incorporation into soils of a variety of substances may greatly increase the amount of water that can be added to a soil before the availability of oxygen, defined as the aeration factor, falls. Sodium alginate, in particular, greatly increases both the water-holding power of a soil and its crumb-stability. Results

Table 1. Aeration Factors of Soils containing Alginate and other Soil Conditioners (Quastel and Webley, ref. 8)

	Percentage water content per dry weight of soil			
	25	37·5	50	62·5
	Aeration factor values*			
Standard soil alone (a heavy clay)	82·7	48·6	29·4	14·9
+ 0·1% sodium alginate	88·4	76·4	42·7	17·2
+ 1·0% sodium alginate	97·4	96·3	67·9	39·0
Garden soil	101·0	83·2	72·0	21·7
+ 1·0% sodium alginate	108·4	112·0	123·4	96·0
Standard soil alone	86·4	55·1	27·0	16·0
+ 1% cellulose acetate	97·1	89·2	58·6	31·7
+ 1% methyl cellulose	91·7	88·8	53·7	21·5
+ 1% carboxymethylcellulose	100·4	94·3	52·6	25·6
+ 2% farmyard manure (dried and ground)	86·2	69·6	32·5	12·6
+ 2% horse dung	104·0	107·5	83·7	76·1
+ 2% ground peat	88·2	68·1	36·5	18·5
+ 2% extract of peat	100·5	94·8	56·9	24·5
+ 2% extract of garden soil	109·4	123·5	86·8	35·3

* Optimal aeration is given by aeration factor = 100

showing the effect of adding alginate to a standard soil depleted of organic matter are given in Table 1. It is seen that the addition of 1 per cent sodium alginate increases the aeration factor of a poor soil to that found for a fertile garden soil. The effect of the alginate rapidly increases to a maximum with increase of concentration. Even a garden soil, with a fairly high content of organic matter, showing good aeration at a high water-content, is affected by addition of alginate so as to improve the hydrophilic properties of the soil (Table 1).

Soil Conditioners

Not only is a polyuronide effective in improving soil structure; cellulose esters such as cellulose acetate, methyl cellulose and carboxymethylcellulose will also improve the air–water relationships in soil (Table 1).

These are substances which may be termed soil conditioners. They improve the structure of a soil by increasing the water-holding power and the soil crumb-stability. This improvement of structure enables more oxygen to become available to the cells, micro-organisms or plant roots, present in soil, at the water contents that the cells need for their metabolism. The increased stability of the soil crumbs diminishes soil disintegration by weathering, etc., and hence diminishes soil erosion. Soil conditioners are not plant nutrients. They yield nothing of service to the plant itself. But, by altering the soil structure, they make more oxygen and water available to the plant roots.

The addition of farmyard manures greatly improves the air–water relationships and crumb-stability of soil, and so does the addition of sewage sludges, composts and refuses generally in proportion to the amount of organic matter present. Extracts of soils and peats may be also very effective (see Table 1) in accordance with their content of organic matter.

These observations make it clear that the commonly occurring forms of organic matter in soils and manures greatly improve the hydrophilic properties and crumb-stability of soils. Yet the practical importance of such substances is greatly dependent on the rate at which they decompose in soil and lose their improving properties. That the addition of alginate to a soil will improve the yield of a crop, grown under glass, was shown by Quastel and Webley[9] and confirmed by Owen[10] and by Hedrick and Mowry[11] (see Table 4); but it soon became certain that the fact that the polyuronide breaks down fairly rapidly in soil militates against its use on a wide scale as a soil conditioner. Again, relatively large quantities are required for the improvement of soil structure (perhaps 5–10 tons per acre) and they may cause harmful effects due to the liberation of cations which have to be added to the polyuronic acid to preserve neutrality.

It was my objective to find a substance, or substances, which would have the improving effects of alginate on soil structure but which would be relatively stable in soil. For use on a large scale, as a substitute for the organic matter of manures and composts, such substances would have to be, weight for weight, more effective than alginate, and without harmful effects on micro-organisms, plants or animals. The advantages of these substances for the improvement of fertility in soils relatively poor in, or depleted of, organic matter would be enormous.

Thanks to the recent discoveries of the scientific staff of the Monsanto Chemical Company, with whose investigations in the field of soil conditioners I have been associated, such substances are now available.

Synthetic Soil Conditioners

Hedrick and Mowry, of the scientific staff of the Monsanto Chemical Co., using initially the manometric technique adopted by Quastel and Webley, and later a modification of the wet-sieving technique of Yoder[12], began the screening of a large number of substances, most of which were synthesized in the Monsanto laboratories, to see if any had improving effects on soil structure. They soon found that only certain water-soluble polymeric electrolytes of high molecular weight were effective at the extremely low concentrations required by practical considerations. One of the most active substances was made by the hydrolysis of polyacrylonitrile to what is predominantly a sodium salt of a polyacid. Other substances that showed excellent effects were also polymers of nearly related structure. These substances had very great improving effects on soil aeration and soil aggregation[11]. A few typical results are shown in Table 2.

Table 2. Aeration Factors of Soils Treated with Polyelectrolytes (Hedrick and Mowry, ref. 11)

Chemical added to standard soil (sandy loam)	Concentration (percentage)	Aeration factors			
		25% water	37·5% water	50% water	62·5% water
Standard soil alone	—	83	55	small	small
Sodium alginate	1·0	108	106	73	26
Sodium alginate	0·1	118	85	28	small
Pectin	1·0	86	77	small	small
Lignin	1·0	90	67	small	small
CRD-186	1·0	130	99	63	30
CRD-186	0·1	128	92	66	40
CRD-189	0·1	113	99	72	35

The two materials on which most work was carried out were *CRD*-189, the sodium salt of a hydrolysed polyacrylonitrile, and *CRD*-186, another carboxylated polymer used as a partial calcium salt. Both these polymers are polyanions, that is, they contain recurring carboxyl groups along the carbon chain.

These polymers have a very great effect upon crumb (or aggregate)-stability and upon soil aeration. A comparison of the effects of preparations of

Table 3. PARTICLES < 0·25 mm. AGGREGATED INTO WATER-STABLE AGGREGATES > 0·25 mm. BY TREATMENT WITH *CRD*-186 (Hedrick and Mowry, ref. 11)

Soil	Percentage aggregation		
	Untreated	0·2% *CRD*-186	0·1% *CRD*-186
Paulding clay	26	29	63
Sacramento clay	8	25	47
Miami silt loam	7	48	96
Cherokee silt loam	7	34	94
Pond loam	1	38	87
Renville loam	5	13	57
Barboursville sandy loam	11	78	86

CRD-186 and *CRD*-189 with those of several other substances on the aeration values of a sandy loam is shown in Table 2. *CRD*-186 and *CRD*-189 gave better aeration values at levels of 0·1 per cent in soil than any of the other materials at 1 per cent. This effect of *CRD*-186 occurs with a large variety of soils. The aggregate stability, as measured by wet-sieving technique, was greatly increased by application of the polymers to the soil, the quantity of large crumbs being increased with a higher rate of application of the polymers. Results of laboratory applications of *CRD*-186 to a number of structurally deficient soils are shown in Table 3. Very pronounced improvement in the workability of all soils treated with *CRD*-186 and *CRD*-189 took place. They became crumbly and friable at high water contents.

Although the primary effect of the polyelectrolyte is on aggregate stability, the percolation-rate through a treated soil may show a hundred-fold increase over an untreated soil. The moisture equivalent of a soil is also improved, and evidence from experiments on the wilting of plants has indicated that all the increase in water held by the soil is available for plant growth. Treatment of soil with the polyelectrolyte results in a reduction of the rate of surface evaporation.

Crumbs of soil treated with *CRD*-186 have remained stable under constant perfusion with water and air for 32 months at 76° F., indicating negligible biological breakdown of the soil conditioner in this period. The untreated crumbs broke down in a few minutes under the same conditions.

An important question concerning the action of the synthetic soil conditioners was whether they affect adversely plant and animal life in the soil. The Warburg evaluation technique indicated that the polymers are not toxic to yeast or bacteria in the soil; moreover, the processes of nitrification are not disturbed. Spectroscopic analyses of kidney beans, wheat and radish plants grown in treated and control soils have indicated that nutrients and trace elements are not rendered unavailable in any way. Nor are the polymers toxic to earthworms, which have appeared in greater numbers in the more friable and well-aerated soil. Rats and chicks have been fed with relatively large doses of *CRD*-186 and *CRD*-189 with no apparent ill effect.

Table 4. EFFECT OF *CRD*-189 AND ORGANIC FERTILIZERS ON GROWTH OF RADISHES IN MIAMI SILT LOAM (Hedrick and Mowry, ref. 11)

Treatment	Dosage (per cent)	Average radish weight factor
None	—	1·0
CRD-189	0·05	1·7
CRD-189 + artificial fertilizer*	0·05	3·4
Sodium alginate	1·0	0·04
Sodium alginate + artificial fertilizer*	1·0	2·6
Commercial compost	1·0	1·1
Activated sewage sludge	1·0	0·6
Rotted cow manure	1·0	2·3
Peat	1·0	1·1

* Artificial fertilizer is 0·1 per cent N.P.K. (6-10-4)

The effects of application of *CRD*-189 and of other substances to a silt loam on the growth of radishes are shown in the results of Hedrick and Mowry, given in Table 4. It will be noted that alginate in the presence of added artificial fertilizers gives excellent growth, though alone it induces little or no growth owing to its mobilization of available nitrogen due to its breakdown in the soil. The synthetic polymer shows no such inhibitive effect.

Crop Yields

According to Allison[13] the application of *CRD*-186 and *CRD*-189 at rates of 0·025 per cent and 0·1 per cent to several saline and alkali soils from the western United States produce high water-stable aggregations, with considerable increases in permeability of soils. Crop yields were favourably affected. Sweet corn was grown on treated and untreated soils; whereas the untreated soils gave poor stands of corn owing to heavy crust formation, full stands were obtained on the treated soils. The quality of corn was excellent and yields were good despite the prevailing high temperatures during the experiments.

Further experiments indicated that administration of *CRD*-186 facilitated removal of salt and exchangeable sodium after irrigation of the soils, a property of importance in soil reclamation.

Martin, Taylor, Engibous and Burnett[14] found also that application of the conditioners to various soils greatly improved water-stable aggregation and such related properties as porosity and permeability. Crop yields, particularly those of corn, oats and carrots, were considerably increased. Some of their results with sweet corn and beet are shown in Table 5.

Table 5. EFFECT OF *CRD*-186 ON AGGREGATION AND SWEET CORN AND BEET YIELDS ON PAULDING CLAY (Martin, Taylor, Engibous and Burnett, ref. 14)

Treatment	Aggregation (particles >0·25 mm.) (%)	Sweet corn		Red beets	
		height (in.)	increase over untreated (%)	weight per 30-ft. row (lb.)	increase over untreated (%)
Untreated	45	12·1	—	6·7	—
0·05% *CRD*-186	85	21·3	76	7·7	15
0·15% *CRD*-186	94	24·4	102	8·7	30

Control of Soil Erosion

Equal in importance to the experiments showing the effects of soil conditioners on the improvement of crop yields on various soils are those demonstrating the remarkable effects of conditioners in the control of soil erosion. Work by Weeks and Colter[15] has shown that surface soil can be satisfactorily stabilized to the erosive action of rainfall by treating the surface with the soil conditioner. The permeable film produced by the conditioners not only stabilizes the soil, but also prevents run-off. The effect was much the same as that due to the application of a high rate of straw mulch. Addition of half to one pound of conditioner to 100 sq. ft. provided satisfactory protection to the soil. One set of results on the effects of artificial rainfall on experimental plots showed that erosion equal to a loss of 50 tons of soil per acre was reduced to a loss of 3 tons per acre by application of the soil conditioner.

'Krilium'

'Krilium' is the trade mark adopted by the Monsanto Chemical Company for substances such as *CRD*-186 and *CRD*-189 sold as soil conditioners. The advent of these conditioners heralds a new phase in agricultural science, of equal importance perhaps with that brought about by the first application of the artificial fertilizers. The possibilities of improvement of fertility in the semi-arid wastes of many parts of the world, which have suffered through neglect of proper cultivation or lack of application of organic matter, are very obvious. But apart from the important economic consequences of the administration to suitable soils of the synthetic soil conditioners, it is clear that these substances afford most valuable material for further studies of the relationship between organic matter and soil fertility.

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SCIENTIFIC CENTENARIES IN 1953

By JOAN M. EYLES

WHILE science, in the modern sense, is often taken to date from about 1600, a year marked, for example, by the publication of Gilbert's "De Magnete", its roots are to be found far back in earlier ages. No one would deny the right of the Greeks to have some mention in a history of science, and few would omit the name of Plato, who is said to have died in 347 B.C., 2,300 years ago. Many biologists, and geologists, too, have heard of Anaximander, who died two hundred years before Plato, in 547 B.C. To include, in this annual review, the names of men who flourished before the Christian era certainly requires a rather optimistic reliance on the accuracy of historical chronology. Our justification must be that, if absolute accuracy be demanded, it might become necessary to omit the names not only of such men, but also of natural philosophers who lived many centuries later. With this apology, we return to Anaximander (*c.* 611–547 B.C.), a citizen of Miletus, and pupil and friend of Thales, who was not only interested in astronomy and geography, but also believed that the first animals were generated from moisture, being thus the first teacher of the doctrine of abiogenesis. He also taught that the ancestors of men were of aquatic origin.

Plato (428–347 B.C.) must be regarded with mixed feelings. His attitude towards physical science, which he thought should be discussed as idealized by the mind rather than as presented by the senses, was called by Sir James Jeans a major disaster for physics. Others admire him for the immense stimulus he gave to the development of mathematics. He insisted on the value of mathematics in the development of logical thought, and over the entrance of his Academy was inscribed, "Let no one enter who is unacquainted with geometry". Although his interest in astronomy redeemed it from the reproach of atheism and thus made it respectable, his opinion that the perfection of the universe required planetary motion to be circular dominated astronomical thought for centuries, until the time of Kepler.

Passing over the Dark Ages, now being illuminated by the questing beams of historians, we come to the thirteenth century A.D., when the founding of a school of science in Oxford can be attributed to Robert Grosseteste, who was born at Stradbroke, Suffolk, about 1173, and died in 1253. Grosseteste studied at Oxford, and later lectured there, ultimately becoming chancellor of the University. About 1224 he was appointed rector of the school established by the Franciscans. Here one of his pupils was Roger Bacon, who said of his master, "One man alone, our Lord Robert, knew the sciences", and it was probably due to the early influence of Grosseteste that Bacon plunged so deeply into scientific studies. Grosseteste himself was one of the earliest of the experimental scientists, and was particularly interested in optics, which he considered to be the basic science. His writings include a discussion of vision, a treatise on the rainbow, and another on comets. He was made Bishop of Lincoln in 1235, an appointment which he held until his death on October 9, 1253.

Coming to more modern times, three men who died in 1553 must be mentioned here. They are Reinhold, the mathematician and astronomer, Fracastoro, the physician, and Servetus, who earned a niche in medical history for his remarks on the minor or pulmonary circulation. Erasmus Reinhold (1511–53) became professor of mathematics at Wittenberg, a university founded in 1502 and closely linked with Luther and the early days of the Reformation. Reinhold, a friend and colleague of Rheticus, who was the first disciple and staunch supporter of Copernicus, applied himself to recalculating to a greater degree of accuracy the tables given by Copernicus in his "De Revolutionibus", and these were published in 1551 as the "Prutenicæ Tabulæ" (so called in honour of Albert, Duke of Prussia, Reinhold's patron). These tables were well received at their first appearance, and were only supplanted by the "Tabulæ Rudolphinæ" of Kepler, published in 1627. Reinhold died on February 19, 1553, at Saalfeld, his birthplace, where he had fled in a vain attempt to escape the plague. A text-book on surveying, including mine surveying, which he had written, was published posthumously at Saalfeld in 1574. This was in use as a standard work in Germany for very many years (see *Nature*, **67**, 42; 1902).

Girolamo Fracastoro (1483–1553) was a Veronese physician who studied at Padua for some years. The fact that Copernicus was a fellow student adds interest to his astronomical work, "Homocentrica". This is an elaborate and somewhat obscure attempt to offer a new planetary system. In it he made the important observation that comets' tails are always turned away from the sun. When, in 1517, certain excavations revealed fossil shells, Fracastoro's comment that they must be remains of once living creatures earned him a place in the history of geology. His fame, however, rests on two medical books. In one, a poem, "Syphilis

sive Morbus Gallicus", he described the disease which came to be known by the title of the poem; and, in his later and more important work, "De Contagione", he classified for the first time modes of infection and gave detailed descriptions of a number of fevers, including typhus.

A younger contemporary of Fracastoro was the unfortunate Spaniard, Miguel Servet y Reves (1509–53), better known as Michael Servetus, who was burnt to death at the stake, at Geneva, by Calvinists for the heretical opinions expressed in his "Christianismi Restitutio", a copy of which was tied to his waist. It was in this book that Servetus described the passage of the blood through the lungs. His account could have attracted little attention at the time, for, of the edition of about a thousand copies, half were burnt with an effigy of Servetus by the Catholic Inquisitor at Vienne on June 17, 1553, and the other half, which had been sent to Frankfurt, were destroyed at the request of Calvin some months after Servetus's death on October 27. It was well over a century before anyone directed attention to his contribution to physiology.

Two naturalists born in 1553 were Thomas Moufet and Prospero Alpino. Moufet (1553–1604), the son of a Scottish haberdasher, was born in London and educated at Cambridge. He studied medicine and later became a fashionable physician. He is remembered for the "Theatrum Insectorum", the first British work devoted to insects, which, however, did not appear until thirty years after his death. It was based on the work of Thomas Penny; but the manuscript, which survives in the British Museum, has many excellent drawings by Moufet. Alpino, another physician, born at Marostica in the Republic of Venice on November 23, 1553, studied at Padua and took his doctor's degree there in 1578. He spent three years in Egypt, and afterwards published several works on the natural history of that country, the best known being his "De Plantis Aegypti Liber" (1592). He enriched the botanical garden at Padua with Egyptian plants.

No outstanding scientist seems to have died in 1653, but two men born in that year have some claim to fame. J. Conrad Peyer, a Swiss zoologist, has his name commemorated in Peyer's patches, the intestinal glands which he figured in 1677, though he was not the first to describe them. He was also the author of a monograph on the compound stomach of ruminants. Peyer died at Basle in 1712.

To have been deaf and dumb until the age of seven, and even after that age always to lack a normal voice and ear, would seem handicap enough in life without inviting further embarrassment by taking up the study of the physics of sound. Yet that was the choice of Joseph Sauveur, born at La Fleche on March 24, 1653. He was a student of the popular Rohault, and was elected to the Royal Academy of Sciences, Paris, in 1696. Although he has been described as the founder of acoustics, it has recently been shown (Lloyd, Ll. S., *Notes and Records Roy. Soc.*, 3, 149; 1941) that much of his work on harmonics had been anticipated by contributors to the *Philosophical Transactions*. He died in 1716.

Before noting bicentenaries, one cannot pass without remark the fact that in 1703, two hundred and fifty years ago, occurred the death of the famous Robert Hooke and the almost equally celebrated mathematician John Wallis.

The year 1753 is an epic one in the annals of natural history in Britain, for it was in the course of that year that Parliament passed "An Act for the Purchase of the Museum or Collection of Sir Hans Sloane and of the Harleian Collection of Manuscripts, and for providing one General Repository for the better reception and more convenient use of the said Collections", that is, virtually, for the foundation of the British Museum. Sloane had died on January 11, 1753, in his ninety-second year, and it was his wish that his enormous collections, which included 40,000 books, as well as manuscripts, coins, and botanical, zoological and mineralogical specimens from all over the world, should pass to the nation. He therefore instructed his trustees to offer them to the King or to Parliament for the sum of £20,000, which he believed to be less than a quarter of their true worth. If the offer was refused then other countries were to be approached, and he named the Royal Academies of Sciences at St. Petersburg, Paris, Berlin and Madrid, in that order. George II showed little interest in the offer when approached by Sloane's trustees, remarking, with good reason, that there was not £20,000 in the Treasury. Parliament, however, urged on by Speaker Onslow, passed the Act referred to above. To raise the necessary sum it was agreed to hold a national lottery, which was intended to produce £100,000. Although the lottery was successful in the latter aim, the traffic in tickets by the jobbers and gamblers who handled the business became a public scandal.

Sloane, the son of a Scot, was born in Ulster in 1660. As a student of botany and medicine in London he became friendly with John Ray and Robert Boyle. He continued his studies in France, and returned to London in 1684 with many rare plants and seeds. In 1687 he went as physician with the Duke of Albemarle to the West Indies. Here, during a stay of some fifteen months, he made an extensive collection of plants, animals and minerals. His collections grew steadily as the years passed, and he purchased or acquired by bequest those of other collectors. Sloane was elected a Fellow of the Royal Society in 1685, and became secretary in 1693. In many ways he did good work for the Society, and in 1727 he succeeded Sir Isaac Newton as president, only resigning fourteen years later, when he felt his advancing years no longer permitted him to discharge his duties satisfactorily. He then retired to his country house in Chelsea, where his museum and belongings were removed, and where he died. His statue by Rysbrack still stands in the Chelsea Physic Garden, and the monument over his grave in Chelsea churchyard has been more fortunate than the church in escaping war damage.

Three days after Sloane, on January 14, 1753, another famous Fellow of the Royal Society died. This was Bishop Berkeley (1685–1753), the philosopher, who, like Sloane, was born in Ireland. Berkeley's philosophical works are well known, as well as his controversy with the mathematicians over the method of fluxions. A different aspect of his character is revealed by his cherished scheme to found a college in the Bermudas, where the English youth of the Plantations could study side by side with "the young American savages". Berkeley was actually successful in persuading Parliament to vote him £20,000 to promote his proposals; but, although he immediately crossed the Atlantic with his wife, and then spent three years in Rhode Island awaiting funds, he eventually despaired of receiving the money and returned to England in 1731. He died quite

suddenly a few months after settling in Oxford, and was buried there in Christ Church.

Three other scientists who died in 1753 call for brief mention. Nicholas Fatio de Duillier (1664–1753) was a Swiss mathematician who spent much of his life in England, and was elected a Fellow of the Royal Society in 1688. He was prominent in the Newton–Leibniz controversy, being the first to accuse Leibniz of plagiarism. He demonstrated to the Royal Society the use of jewelled bearings for watches, and also wrote on navigation. Becoming involved with a group of religious fanatics, in 1707 he appeared in the pillory at Charing Cross for publishing prophecies likely "to terrify the Queen's people". After some years abroad he retired to Worcestershire, where he died on April 24 in his ninetieth year.

Georg Wilhelm Richmann, one of science's martyrs, was born at Pernau in 1711, and became professor of experimental philosophy at St. Petersburg in 1745. He deduced a formula for calculating the temperature of mixtures, which was used by Wilcke in his experiments on the melting of snow. Richmann met his end in an unusual way. An enthusiastic student of electric phenomena, he was killed in the summer of 1753 during a thunderstorm by a flash of lightning which passed through his body from a lightning collector with which he was experimenting. The strange manner of his death was made known in two communications to the *Philosophical Transactions*.

Thomas Melvill (1726–53), a Scot, was only twenty-six when in 1752 he communicated a paper to the Edinburgh Philosophical Society in which he described the examination through a prism of flames into which different salts had been introduced. These experiments establish him as one of the pioneers of spectrum analysis. He died in December of the following year at Geneva.

The stars of 1753 seem to have shone favourably for the birth of inventors, for six men born in that year whom we notice all had a strong bent towards practical science. The best known of them is Sir Benjamin Thompson, Count Rumford, who led a varied and colourful life. Born in Massachusetts on March 26, 1753, he arrived in England in 1776, his Royalist sympathies having made it advisable for him to leave America. In the War of Independence he served as an officer in the British Army, but at the end of the war, in 1783, he returned to England again. Soon afterwards he set out to visit Europe. In 1784 he entered the service of the Elector of Bavaria, and, becoming his principal adviser, he carried out many social reforms. It was during this period that he made in Munich his famous experiments on heat. He had been knighted by George III in 1784, and seven years later was created a Count of the Holy Roman Empire, when he chose to commemorate in his title the Massachusetts township (now Concord) with which he had close associations. Returning to London in 1798, he applied himself enthusiastically to drawing up proposals for founding a public institution "for diffusing the knowledge and facilitating the general introduction of useful mechanical inventions and improvements". These proposals led to the founding of the Royal Institution in 1799. In his house in Brompton Row (a little east of Brompton Oratory, in what is now Brompton Road) he installed the many improvements in heating to which he had devoted so much of his time. The house was freely exhibited to visitors from all classes of society, and for several years attracted curious sightseers. Its furniture included beds disguised by day as elegant sofas, built-in cupboards, and hinged panels which could be raised to form writing-tables near the fire or window. Rumford spent his last years in France, where he died at Auteuil at the age of sixty-one.

Another somewhat unusual character born in 1753 was Charles, third Earl Stanhope. Elected a Fellow of the Royal Society at the age of nineteen, he devoted much of his income to experiments in natural philosophy. He made two calculating machines, now in the Science Museum at South Kensington, and constructed the first iron printing press. The latter, together with his invention of stereotyping by a plaster process, he presented to the Clarendon Press in 1805, and they were in use for some years. Stanhope died in 1816. A man in a very different walk of life to the noble earl was Samuel Crompton (1753–1827), inventor of the spinning mule which did so much to raise the status of the cotton industry. Other contemporaries were Edward Troughton (1753–1835), the renowned maker of astronomical instruments, who received the Copley Medal of the Royal Society in 1809, and William Nicholson (1753–1815), who with Sir Anthony Carlisle was the first to construct a voltaic pile in Britain, and with it observed the electrolytic decomposition of water. He was also the founder and editor of *Nicholson's Journal*, one of the first of the independent scientific journals in Britain. We must also mention F. K. Achard (1753–1821), the German chemist who discovered a commercial method of extracting sugar from the sugar-beet, so laying the foundation of an industry which rapidly became of considerable economic importance.

In 1853, geological science suffered two losses in the deaths of C. L. von Buch (born 1774) and H. E. Strickland (born 1811). Von Buch had been a pupil of Werner at Freiberg and an intimate friend of Humboldt. He made many valuable contributions to geology, in particular a description of the Canary Islands, which he visited in 1815. He also made important observations on the change of sea-level along the Swedish coast, compiled the first geological map of Germany, and made notable contributions to palæontology. Von Buch reached the ripe age of seventy-nine; but Strickland was only forty-two when he was killed by a train while making geological observations in a railway cutting near Retford. He was the author of a number of geological and ornithological papers, and in 1850 was appointed deputy reader in geology at Oxford, during the illness of Buckland. Strickland was one of the founders of the Ray Society, and edited for the Society the "Bibliographia Zoologiæ et Geologiæ" based on the manuscripts of Agassiz, though on account of his untimely death the fourth volume was completed by his father-in-law, Sir William Jardine. Strickland was also joint author of a classic memoir on the dodo.

French scientists lost several of their number during 1853, the best known being Dominique François Jean Arago, physicist and astronomer, born near Perpignan in 1786. At the age of eighteen he became secretary to the Observatory in Paris, and two years later accompanied Jean Baptiste Biot to Spain in order to assist him in completing the meridional measurements begun by Delambre. After Biot had returned to Paris, Arago became involved in the most fantastic adventures, which included imprisonment in a fortress, escape in

a fishing boat, and capture by a Spanish corsair. Eventually he arrived back in Paris, still in possession of the records of his survey, which he had preserved through all his vicissitudes. Soon after his return he was elected to the Academy of Sciences at the remarkably early age of twenty-three, and about the same time Napoleon appointed him as one of the astronomers of the Royal Observatory. Arago carried out notable researches on the polarization of light. He also discovered the "magnetism of rotation", which was not interpreted until Faraday discovered electro-magnetic induction. Arago received the Copley Medal of the Royal Society in 1825 and died on October 2, 1853. His compatriot, Auguste Laurent (1808–53), a brilliant young chemist who died a few months before, on April 15, had led a very different life from that of the accomplished and successful Arago. Always struggling against poverty, and apparently ostracized by his French colleagues, some of his experimental work was carried out in a damp cellar while he worked as assayer to the Mint. He is credited with a number of discoveries in the field of organic chemistry. He died of consumption, and his famous "Méthode de Chimie" was published posthumously. Another organic chemist, Leopold Gmelin (1788–1853), perhaps the best known of a distinguished German scientific family, died two days before the unfortunate Laurent. He was professor at Heidelberg, and the author of the great "Handbuch der Chemie", translated into English (1848–72) for the Cavendish Society by Henry Watts.

Other deaths in the same year were those of C. J. Doppler (born 1803), the Austrian physicist who discovered the principle named after him, K. J. B. Karsten (born 1782), the German mineralogist, and M. J. B. Orfila (born 1787), the celebrated toxicologist. In America the deaths were reported of Sears Cook Walker (born 1805), astronomer, and William Beaumont (born 1785), physiologist. The latter, an American surgeon, for many years made observations on the stomach of a French-Canadian trapper who had suffered a severe gunshot wound. The persistent opening in the wall of his stomach permitted Beaumont to make experiments which threw considerable light on the nature and flow of the gastric juice.

A number of particularly distinguished men were born in 1853, including four who received Nobel Prizes. Wilhelm Ostwald, born at Riga on September 2, held a professorship of chemistry at the Baltic Polytechnical School of Riga during 1883–87, and then became professor of physical chemistry at Leipzig. When he retired in 1905, at his own request, in order to devote himself to research, he was nominated by the Emperor of Germany as the first exchange professor with the United States. In 1909 he received the Nobel Prize for chemistry. His contributions to physical chemistry were numerous, and too well known to need detailing here; but it is worth recalling that in the industrial field he developed the process for producing nitric acid by the catalytic oxidation of ammonia, which became the main source of Germany's supply of nitric acid during the First World War. Ostwald died on April 4, 1932.

A contemporary of Ostwald's, who worked with him for a time at Leipzig, was Ernst Beckmann (1853–1923), who became director of the laboratory for applied chemistry there in 1897, a position he held until 1912. The Beckmann thermometer and Beckmann freezing-point apparatus for the determination of molecular weights are well known.

An outstanding figure of the period under review was the Dutch physicist, Hendrik Antoon Lorentz, born at Arnheim on July 18, 1853. At the age of twenty-five he was appointed professor of theoretical physics at Leyden, and occupied the chair there with great distinction for forty-five years. The Lorentz transformation, made known in 1903, became the basis of the theory of special relativity. With Zeeman, he was awarded the Nobel Prize for physics in 1902. He was a Foreign Member of the Royal Society, and received the Rumford Medal in 1908 and the Copley Medal in 1918. He died at Haarlem on February 4, 1928.

Another eminent Dutchman, only a few months younger than Lorentz, was the genial Heike Kamerlingh Onnes (1853–1926). Born at Groningen, he passed several years at Heidelberg under Bunsen and Kirchhoff. Appointed professor of experimental physics in Leyden in 1882, he founded the famous Cryogenic Laboratory, where he achieved his great triumph, the liquefaction of helium, in 1908. Like Lorentz, he was awarded a Nobel Prize for physics (1913), and was a Foreign Member of the Royal Society. A fellow student of Onnes at Heidelberg in 1872 was W. F. Hillebrand (1853–1925), the American geochemist, who after joining the U.S. Geological Survey in 1880 became specially distinguished for his analyses of rocks and minerals. He made many analyses of the mineral uraninite between 1882 and 1892, and was puzzled by the presence in it of an inert gas, afterwards identified by Ramsay in 1895 as helium. Later, his highly skilled analyses of radioactive minerals were used in determinations of the age of the earth by Holmes and others.

A distinguished Italian mathematician, M. M. G. Ricci (1853–1925), who developed the tensor calculus, also comes into this period.

In the biological sciences two men must be mentioned. Albrecht Kossel (1853–1927), trained as a physiologist, devoted his researches to chemical subjects and became one of the leaders in the then new science of biochemistry. He was professor of physiology at Heidelberg during 1901–23, and did notable work as director of the Institute for Protein Investigation. He was awarded the Nobel Prize for Medicine in 1910, and died at Heidelberg on July 6, 1927.

No admirer of the work of Pasteur will have forgotten his devoted young assistant Emile Roux (1853–1933), who was so closely connected with the renowned researches on anthrax and rabies. With Alexandre Yersin he discovered the diphtheria toxin, an achievement leading to the discovery of the antitoxin by Emil von Behring in 1890. In 1904, Roux succeeded Duclaux as director of the Institut Pasteur in Paris. He died just before his eightieth birthday, on November 3, 1933, and received a national funeral. Roux had been elected a Foreign Member of the Royal Society in 1913, and received the Copley Medal in 1917.

In conclusion, it seems worth reminding readers that at the anniversary meeting of the Royal Society in November 1853, the president, the Earl of Rosse, informed the Society of a memorial made to the Government bearing some two hundred signatures, including those of many Fellows of the Society, requesting a building for the housing of scientific societies in the metropolis. As a result of this petition, Burlington House was eventually made available to the Royal and other societies, after a site at South Kensington had been refused by men of science on account of its inconvenience.

GEO-MORPHOLOGY OF F_2-REGION IONOSPHERIC STORMS*

By Dr. D. F. MARTYN, F.R.S.
Radio Research Board, Australia

DURING the International Polar Year of 1932–33, Appleton and Ingram[1] established a correlation between magnetic storms and temporary reductions of F_2-region electron densities at high latitudes. At moderately high latitudes, too (Slough, England), they found that F_2-region perturbations were associated with magnetic storms; but here the perturbation was sometimes an increase followed by a decrease of F_2-maximum electron density. At equatorial latitudes Berkner and Seaton[2] showed that the normal tendency was for F_2-electron densities to increase during magnetic disturbance.

On the basis of these facts, Appleton and Piggott[3] have proposed a system of classification of ionospheric storms which bears a superficial resemblance to that adopted by Birkeland for magnetic storms (for example, 'negative polar storm', 'positive equatorial storm'). On this method of classification certain anomalies appear; for example[3], "Washington (lat. 38·5° N.; long. 77° W.) mostly behaves like an auroral-zone type of station, whereas Burghead (lat. 58° N.; long. 3° W.) and Leningrad (lat. 60° N.; long. 30° E.) are predominantly non-auroral type medium-latitude stations, although all three lie on the same magnetic latitude".

This tentative classification of Appleton and Piggott's is based on the study of noon values of F_2-electron densities. Martyn[4] has already pointed out that there is a pronounced diurnal (local time) variation in F_2-region parameters during magnetic disturbance. This is found to be big enough to produce inconsistencies if Appleton and Piggott's mode of classification be followed. For example, if midnight instead of noon values be taken, auroral observatories show an increase of F_2-electron densities.

A satisfactory method of classification of ionospheric storms almost necessarily presupposes the existence of a plausible theory of their occurrence. Until 1950 it was generally supposed that such storms were due to local impact of particles from the sun, which in high latitudes heated the ionosphere, so reducing electron densities, and in low latitudes contributed to the ionization in some unexplained way. In that year Martyn[5] put forward the hypothesis that disturbances of the F_2-region associated with magnetic activity were due in all cases (save possibly 'great' magnetic storms) not to direct particle bombardment, but to the effect of an electrostatic field which spreads over the earth from the intense current systems set up in the auroral zones during all magnetic storms. This field, if it has the magnitude and phase necessary to produce the solar diurnal (S_D) current system in the ionosphere, will, it is found, produce the observed perturbations of the F_2-region by causing electron (and ion) drifts in accordance with concepts previously advanced[6] to explain tidal phenomena in the ionosphere.

Using this theory as a preliminary hypothesis, an extensive study has been made, during the past three years, of the geo-morphology of F_2-ionospheric perturbations associated with magnetic storminess. On this basis it was logical to examine both S_D ($f^0_{F_2}$ and h'_{F_2}) and D_{st} ($f^0_{F_2}$ and h'_{F_2}) using the methods and terminology developed by Chapman for the corresponding magnetic variations; namely, in the case of the ionospheric D_{st} (disturbance, storm-time), to measure time from the beginning of the sudden or gradual commencement of the corresponding magnetic storm.

Using this procedure the following conclusions have been reached: All major perturbations of the F_2-region, save those associated with the relatively small travelling disturbances[7] of unknown origin, are associated with magnetic storms. There is no evidence that such storms travel from the polar zones, with travel-times of the order of hours or days, as has been suggested from time to time. The ionospheric storm at all latitudes begins, either simultaneously with, or in a time less than one hour after, the commencement of the corresponding world-wide magnetic storm. The effect of a magnetic storm on the F_2-region depends markedly on the season. In summer, the general tendency of a storm is to lower electron densities, and to raise the heights at which

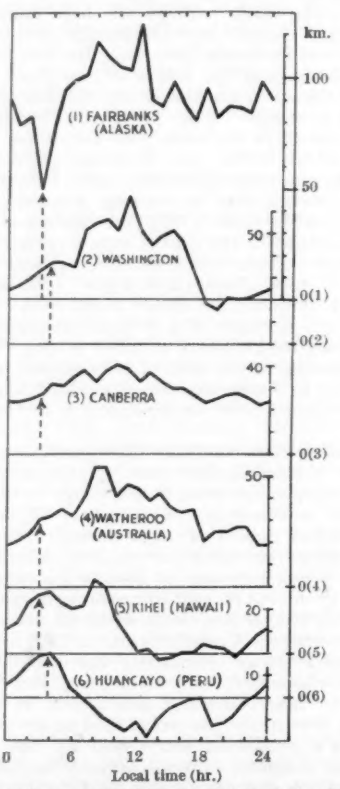

Fig. 1. $SD(h'F_2)$ average diurnal variation of h'_{F_2} (minimum equivalent height of F_2-region) for five International magnetically disturbed days each month minus same variation for five International quiet days each month, for:
(1) Fairbanks, magnetic latitude (Φ) = 64·7° N., April 1944–Dec. 1948.
(2) Washington (Φ = 50·3° N.), Jan. 1941–June 1948.
(3) Canberra (Φ = 44·0° S.), March 1937–June 1948.
(4) Watheroo (Φ = 41·7° S.), Jan. 1944–Dec. 1948.
(5) Kihei (Φ = 20·9° N.), March 1946–Dec. 1948.
(6) Huancayo (Φ = 0·6° S.), Jan. 1942–Oct. 1948.
The scale unit is 10 km. in each case.

* Substance of papers presented at the recent meetings of the International Scientific Radio Union and of the Mixed Commission on the Ionosphere, at Sydney and Canberra, Australia.

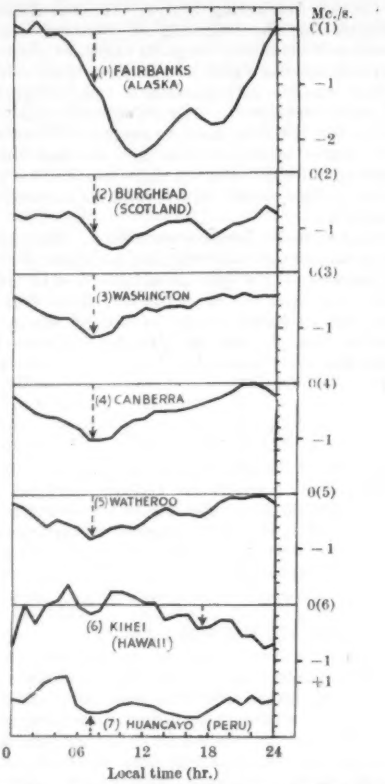

Fig. 2. $S_D(f^0F_2)$ average diurnal variation of f^0F_2 (critical penetration frequency of F_2-region) derived as for $h'F_2$ in Fig. 1 for:

(1) Fairbanks (see Fig. 1).
(2) Burghead ($\Phi = 60{\cdot}7°$ N.), Jan. 1943–Dec. 1946.
(3) Washington (see Fig. 1).
(4) Canberra (see Fig. 1).
(5) Watheroo (see Fig. 1).
(6) Kihei (see Fig. 1).
(7) Huancayo (see Fig. 1).

The scale unit is 0·2 megacycle per second in each case.

the maximum densities occur. In winter the densities are reduced in the morning hours, and raised in the afternoon hours.

There is a general tendency for electron densities to be lowered on the average at high latitudes and raised at low latitudes. However, as mentioned above, this statement has to be taken in conjunction with the local time at which such densities are studied. For example, at local midnight, electron densities are above average at high latitudes and below the average in tropical latitudes not too near the magnetic equator (for example, Hawaii, Fig. 2).

The S_D (local time) variation is large and predominantly diurnal (Figs. 1 and 2). Densities are lowest in the mornings and highest in the evenings. The phase of the diurnal variation advances by about four hours as one passes from auroral to equatorial latitudes. At Fairbanks (Alaska) minimum densities (and greatest heights) occur at 11 hr. local time; in equatorial zones at about 07 hr.

There is no evidence that any magnetic storm affects the northern and southern hemispheres differently, when due allowance is made for the seasonal effect described above. The initial effect of any magnetic storm on the F_2-region depends markedly on the local time of commencement. If the storm commences at a time when the local $S_D(f^0F_2)$ curve is at its highest point (say 22 hr. at temperate latitudes), the initial disturbance is a decrease of f^0F_2 (that is, the variation initially follows the $S_D(f^0F_2)$ curve). If, on the other hand, the storm commences at, say, 10 hr., the initial effect is an increase in f^0F_2. It is suggested that the anomalous result found by Appleton and Piggott[3] for Washington is due to the inclusion of a preponderance of storms commencing in the (local) evening hours in their data. When allowance is made for this bias, Washington is found to have the appropriate characteristics of a temperate-latitude station. This effect is shown for Watheroo in Fig. 3, which exhibits the departure of f^0F_2 from normal during the first three days of magnetic storms which commenced between (*A*) 08 and 11 hr. local time, and (*B*) 20 and 23 hr. local time. (In group *A* are included 17 storms, in *B* 11 storms.) It will be seen that on Appleton and Piggott's classification Watheroo would be classified as a temperate-latitude station on the basis of group *A* storms, and as an auroral station on the basis of group *B* storms.

It appears that F_2-region ionospheric storms, like magnetic storms, have a unitary character, and may be regarded as manifestations of a single world-wide phenomenon. The local effects produced by this single phenomenon, which it is suggested is the electrostatic field of the S_D current system, depend markedly on local time and season.

The theoretical (Chapman) diurnal, seasonal and latitude characteristics of the F_2-region are normally perturbed by solar tidal electric fields, along lines previously reported[3]. It appears that the phase of the additional electric field present during magnetic storms is such as to increase these perturbations at high latitudes, and to reduce them at low latitudes. This is specially obvious at Huancayo, where the normal daily departures of the F_2-region from 'Chapman' behaviour are large, leading to noon

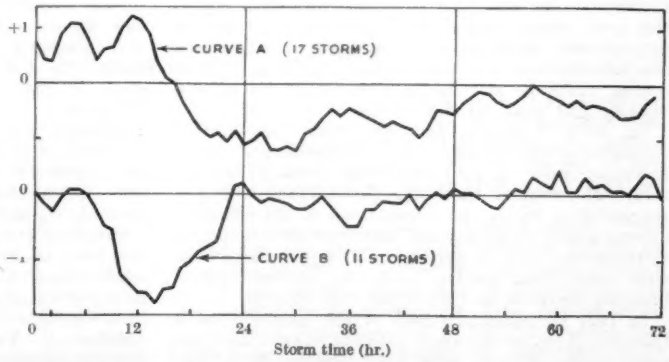

Fig. 3. $D_{st}(f^0F_2)$ at Watheroo. Hourly values of f^0F_2 for first three days of magnetic storms minus corresponding hourly values for magnetically quiet days, for (*A*) storms commencing between 08 and 11 hr. local time: and (*B*) storms commencing between 20 and 23 hr. local time

minima of ionization density, and abnormally rapid pre-dawn reduction of these densities. During magnetic storms these anomalies are removed, and the diurnal variation of F_2-region electron densities in the vicinity of the magnetic equator approximates more closely to that anticipated for a simple 'Chapman' region.

This work is published by permission of the Radio Research Board of the Commonwealth Scientific and Industrial Research Organization. I am indebted greatly to Miss B. Hardwick, who has supervised the reduction into appropriate form of ionospheric data from co-operating observatories.

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OBITUARIES

Mr. H. C. Sampson, C.I.E.

Hugh Sampson, whose death at the age of seventy-four occurred on November 29, was an authority on tropical agriculture. His knowledge was gleaned during service in many countries. Born in Simla and educated at Bedford School and the University of Edinburgh, he joined the Transvaal Department of Agriculture in 1903; but after a couple of years he accepted the post of agricultural expert to the Madras Court of Wards. The great renaissance of Indian agriculture was just beginning, and Sampson was one of the first officers to join the newly constituted Indian Agricultural Service. For the next fifteen years he worked in Madras, first as deputy director, with headquarters at Tinevelly, and later as director. His work during this period led to marked improvement in the agricultural methods of the Madras Presidency. He was the first to admit the difficulties that held back progress. Among these were the limitations caused by debt and the system of tenure, and he always, therefore, advocated a cautious approach and preached the necessity for the thorough investigation of natural methods before attempting to discard or alter them. In spite of these hindrances, he was able to effect improvements in the seed supply and modifications in the types of agricultural implements. A notable example was the introduction of a long-stapled American Upland cotton which he introduced from Cambodia after a visit he had made to Indo-China.

In 1923 Sampson resigned from the Indian Agricultural Service and went to Nyasaland as cotton specialist under the Empire Cotton Growing Corporation. He worked there for three years and was successful in laying the foundations of the excellent experimental work that has been carried out in this Protectorate, and in sorting out the mixed cottons that were then grown, initiating modern plant-breeding methods and a proper seed supply.

In 1927 he joined the staff of the Royal Botanic Gardens, Kew, as economic botanist, a post that had been newly created with the connivance of the Empire Marketing Board. He retired from Kew in 1938, but during his term of office he visited the Caribbean Colonies and wrote reports on them for the Empire Marketing Board. He was instrumental in organizing the dispatch of planting material of several new economic crops to various Colonies where prospects seemed suitable. Perhaps the most notable of these was the introduction of tung oil into Nyasaland and Swaziland. His 'magnum opus' was the publication of a *Kew Bulletin* entitled "The Cultivated Crop Plants of the British Empire and the Anglo-Egyptian Sudan", a work that entailed an immense amount of labour and which remains a standard work of reference.

Sampson had a likeable character. His quiet voice, whimsical manner and kindliness endeared him to all his associates. He had the satisfaction in retirement of knowing that the work he had done during those early days in India has had a lasting effect, and one imagines that his memory is still green and respected in the Madras Presidency.

G. Evans

Dr. J. Henderson Smith

John Henderson Smith, who died on November 28, graduated from Baliol College, Oxford, in 1898, proceeded to Edinburgh, where he took his medical degree in 1903, and then returned to Oxford as Philip Walker Student in pathology. Later, he was appointed bacteriologist to the Lister Institute. Here he did some promising work on immunology; in one of his early investigations, published in 1907, he demonstrated that the concentration of anti-toxin in the blood at any time depends on the route of introduction. Later, in conjunction with Brooks, he studied the influence of the dose of antigen on the output of the antibody and on its time of appearance; the results were published in 1912. All this work was characterized by cleanness and accuracy of experimental technique, and by careful and critical examination of the results; he seemed to have the prospect of a very promising career in his subject.

Then, unfortunately, he was struck down with tuberculosis, and although he made gallant attempts to continue his work he had to give it up; in 1916 he left the Institute.

Henderson Smith refused, however, to abandon scientific work. Fortunately the Rothamsted Experimental Station was beginning to expand and had brought plant diseases within its ambit. Its policy was to bring in young people each well trained in some pure science which he or she could apply to the problems of the Station; in connexion with the new developments, it was desired to find someone well grounded in human or animal pathology who could introduce new ideas and methods into the study of plant pathology. Henderson Smith was attracted to the work; by 1919 he had recovered sufficiently to join the staff, and the healthy surroundings and the devoted care and attention of his wife enabled him to stay out his full term of service with no further serious trouble. He retired on reaching the age limit in 1940.

Henderson Smith's first investigations at Rothamsted were on the growth-rate of fungal hyphæ, but he soon turned to more fundamental studies of the killing of fungus spores by phenol; these proved to be a valuable contribution to the general theory of disinfection. Plant virus diseases were then coming into prominence and he turned over to them: his work soon attracted attention, and following a request from the Imperial Mycological Conference of 1929 that virus diseases should be more fully studied,

the Empire Marketing Board provided funds for a research team under his leadership. The work included the nature of the cell inclusions—the so-called X-bodies—the concomitant bacteria in virus diseases, and the size of the viruses.

When W. B. Brierley left Rothamsted in 1932 to occupy the chair of agricultural botany in the University of Reading, Henderson Smith was appointed to succeed him as head of the Department of Mycology; it continued to expand and to attract able young people, becoming one of the most vigorous at Rothamsted. He served as president of the Association of Applied Biologists, and was also president of the Virus Section of the 1939 International Congress of Microbiology.

'H. S.', as he was always affectionately called, enjoyed much quiet esteem among his colleagues. Under his wife's watchful care he had to be cautious in all matters pertaining to health, but this did not restrict his interests. Like his wife, he was well read; in addition, he was a recognized authority on book plates, of which he was a discriminating collector, and an ardent and competent player of golf and of bridge. He never sought popularity, but his courage and his persistent determination to go on with his work in spite of threatened ill-health won him much respect from those who knew him well.

E. JOHN RUSSELL

Dr. Franz K. Nagelschmidt

FRANZ NAGELSCHMIDT, a pioneer of physical medicine, died on October 4 in Manchester. He was born in Berlin on January 29, 1875. He studied medicine, but soon became also interested in physics, for he thought that the many advances in modern experimental physics taking place at the end of the past century could be utilized for medical purposes. He went first to Copenhagen to work with Finsen, the founder of light therapy. He then returned to Berlin and established a light treatment institute at the Charité, where he installed the first X-ray unit for therapeutic purposes in 1903. In 1904, he founded a light treatment institute in Breslau, where he applied radium rays for the first time for treatment. In 1906, he settled in Berlin and founded the Finsen Clinic, of which he was in charge until 1933. Here he developed diathermy—the name was coined by him, and generally adopted, for the creation of heat inside the tissue by external application of electric currents, his best-known discovery. He also designed and introduced an ultra-violet lamp without water cooling. This lamp, the prototype of modern ultra-violet lamps, carried his name for several years. In 1911, he designed an apparatus to produce 'electro-rhythmic current' for electrical vibration treatment. In 1912, he invented the neon lamp, originally for medical purposes.

In 1933, Dr. Nagelschmidt left Germany for Great Britain, where he was immediately made an honorary consultant of physiotherapy at the Jewish hospital in London. In 1934, he had been awarded the "Golden Key" of the American Congress of Physical Therapy for "outstanding service to the science of physical medicine". In 1936, he qualified in Edinburgh as a medical practitioner and settled in Manchester as honorary consultant in physiotherapy at the Jewish hospital. He also founded a private therapeutic institute where he practised physiotherapy and carried out research until about three hours before his death.

Nagelschmidt was a man of many talents and many interests, in art as well as in science. In spite of all his achievements, he was a very modest man. This modesty made him call all the therapeutic establishments installed by him after his teacher Finsen, and this may explain why the scientific world knows the name of Finsen, who first conceived light therapy, much better than the name of Nagelschmidt, who developed it and who added all the other forms of physiotherapy to it. It may also account for the fact that few honours were bestowed on this great man.

W. ROMAN

WE regret to announce the following deaths:

Mr. E. G. Dymond, reader in natural philosophy in the University of Edinburgh, on October 26, aged fifty-two.

Prof. M. G. Evans, F.R.S., professor of physical chemistry in the University of Manchester, on December 25, aged forty-eight.

Prof. A. H. Jameson, emeritus professor of civil engineering in the University of London (King's College), on December 23, aged seventy-eight.

Prof. E. Allison Peers, Gilmour professor of Spanish in the University of Liverpool, and author, under the pseudonym "Bruce Truscot", of books on the functions of universities in present-day Britain, on December 21.

NEWS and VIEWS

A Further Cœlacanthid Fish

ON December 22, 1938, a fish of Crossopterygian type was taken by trawl-net, at a depth of about 40 fathoms some miles west of East London. The animal was unquestionably alive when caught. It was 1,500 mm. in total length and weighed 127 lb. The colour was a bright metallic blue which faded to brown with preservation. Miss Courtenay-Latimer, curator of the East London Museum, took charge of the catch, and eventually Prof. J. L. B. Smith, now research professor of ichthyology in Rhodes University, Grahamstown, was able to examine it (*Nature*, 143, 455; 1939). Prof. Smith immediately named it *Latimeria chalumnæ* gen. et sp. nov., as a tribute to Miss Latimer. This discovery naturally aroused great interest, although, in spite of Miss Latimer's care, much disintegration of parts had occurred. Until then, only fossil records of cœlacanthid fishes, believed to have been extinct for about fifty million years, had been available. Further details of this fish were published in *Nature* (143, 748; 1939) by Prof. Smith.

Now comes a report of a further catch. This second fish was reported as having been caught on December 20 off the island of Anjouan in the Comoro group, two hundred miles west of Madagascar. It was reported to be about 5 ft. long and to weigh about 100 lb. On December 29, the fish was received by Prof. Smith, who had flown to the island to retrieve it and to take it to Rhodes University for further study. Preliminary reports suggest that Prof. Smith is very satisfied with the state of preservation of the

fish, and he has named it *Malania anjouanæ*, as a tribute to Dr. Malan, the Prime Minister, who had placed an aeroplane at Prof. Smith's disposal. It is of interest to note that the fish was caught in 20 m. of water by an Arab, using a line, and that the islanders claim that two or three such fish are caught each year in the same region and sold in the local market. Further details will be awaited with considerable interest.

University of Leeds

At a meeting of the Court of the University of Leeds on December 17, the vice-chancellor, Dr. C. R. Morris, commenting on the difference of opinion as to whether national service should be done before or after embarking on university work, said that while war service in general encourages the development of the intellectual life, there is evidence that national service in peace-time is inimical to it and ability and personality are not developed in the same way. As regards research in universities, he said that, while there may be some research which it would be wrong for universities to undertake, the great increase in the extent of university research in recent years is an advance in the right direction. The national interest requires full use of the highly trained and expert man-power to be found in university departments, and this would require the provision of more money for the maintenance of departments. It has been, he said, a cardinal point of policy with the University of Leeds also to maintain a strong and numerous teaching staff in relation to students, and experience is showing without doubt that this policy is right. Dr. Morris referred to disappointments in progress with halls of residence: more progress has been made with accommodation for women than for men during the past two or three years. The construction of the new refectory and staff house is well advanced and work on the Rayon Building for the Department of Textile Industries is expected to begin in March or April.

British Chemical Abstracts

A question was asked by Sir W. Wavell Wakefield in the House of Commons on December 16, inquiring whether the Government intends to give any effective support to prevent the termination of the arrangements for the publication of *British Chemical Abstracts*. In reply, Mr. A. E. H. Molson said that the Lord President of the Council was informed of the difficulties that had arisen in regard to the publication of *British Chemical Abstracts*, and that when the question was referred to his predecessor the latter had asked for the advice of the Royal Society. Certain recommendations have recently been received from the Royal Society, designed to ensure the continued publication of these abstracts. These recommendations are at present being examined as a matter of urgency, in consultation with the chemical industry.

Studies on Primates

The two recent parts of Vol. 122 of the *Proceedings of the Zoological Society* (Part 1, May; Part 2, August, 1952) contain, *inter alia*, interesting and valuable contributions to our knowledge of the Primates, living and fossil. The former part has a paper by W. C. Osman Hill, Annie Porter and Margaret D. Southwick on the natural history and parasites of the tarsier, *Tarsier carbonarius*, based on studies of two females and one male which were kept alive in the Society's gardens for 692, 957 and 1,043 days, respectively. During these times careful daily records were kept of their behaviour, including the sexual cycle and their reactions to various situations and conditions. The paper also includes an account of their ailments and treatments and a detailed study of their endoparasites. W. C. Osman Hill also describes fully the external features and visceral anatomy of the rare and almost unstudied African olive colobus monkey, *Procolobus verus*. The identity and relationships of a number of the members of the Colobidæ are not satisfactorily established, and this study, with its comparative treatment, is a step towards that end. During 1949–51 the British–Kenya Miocene Expedition collected a considerable amount of fossil hominoid material, which is reported upon by Prof. W. E. Le Gros Clark in Part 2. He has been able to add important details concerning five species belonging to the genera *Proconsul* and *Limnopithecus*. The same part also contains an extensive monograph by Dr. A. J. Haddow on the African red-tailed monkey, *Cercopithecus ascanius schmidti*. This is a most meticulous account of the identification, synonymy, biology, ecology and distribution of this species based on the examination of 143 specimens and on countless observations in field and laboratory. It is a more complete study of any African monkey than has been published heretofore, and clears up some of the confusion that exists in this important group of animals.

Fakes and Forgeries in Museum Objects

In a paper on "Fakes and Forgeries in Museums" (*Museums Journal*; September 1952), Dr. H. J. Plenderleith, of the Research Laboratory of the British Museum, gives some interesting examples of how the scientific worker can help scholarship in the detection of deception. The methods used are naturally those mainly associated with non-destructive testing. Among many interesting tests, he relates the study of a Greek bronze which could not be sectioned. A coin of known date and composition from Delhi was used as control; it showed certain surface features of decay. When sectioned, however, it revealed a crystalline structure with evidence of inter-crystalline oxidation and even a copper-rich area arising from the secondary reduction of cuprite. Micro-cracks were revealed in the brittle interior and an internal granulated condition at the deepest points of attack. The same tests applied under the base of the Greek bronze yielded results which indicated its genuineness. Such micro conditions would be impossible to fake. The patina of the bronze was, however, olive green in colour, easily detached and showed no foundation of cuprite. These suspicious observations were confirmed by X-ray diffraction. It was therefore clear that, although the bronze was genuine, the patina had been faked.

Newton's "Principia"

In the March issue of *Scripta Mathematica*, a quarterly journal devoted to the philosophy, history and expository treatment of mathematics (Yeshiva University, 20th and Northampton Streets, Easton, Pa.), an article is published under the title "A Survey of the Number of Copies of Newton's Principia in the United States, Canada, and Mexico". The survey was inspired by the late Dr. David Eugene Smith and has been carried out by Frederick E. Brasch, a consultant in bibliography, of Stanford University, California. The article directs attention to the Western trend of scientific progress

and to the distribution of books—a symbol of this progress. The author rightly maintains that Newton's "Principia" is one of the great books which have laid the foundation of modern mathematics and astronomy and have influenced many aspects of the physical sciences as well as various phases of philosophy and religion. A brief outline of Newton's life is followed by a more detailed study of the "Principia" and its publication, with special reference to the third edition. An interesting section is devoted to the annotated and corrected editions of the "Principia" and includes an account of the so-called folio size copies of the third edition. In the statistical survey with which the article concludes, some seventy-two copies of the "Principia" and their locations are mentioned with appropriate references and comments. The whole forms an interesting and instructive piece of research both from the bibliographical and cultural points of view.

Plant Growth Regulators

THE rapid expansion of our knowledge of the natural plant growth substances and the almost unprecedented success of the practical application of closely related synthetic chemical homologues in agriculture and horticulture have brought with them the usual terminology difficulties, which have unfortunately been aggravated by careless and ambiguous usage, particularly by workers in applied fields of research. Plant physiologists in general have been conscious of the need for a review of this terminology and for authoritative definitions based on modern knowledge and ideas on action and function in the plant. This need has perhaps been felt most strongly in the United States, where an American Society of Plant Physiologists study committee, composed of four leading workers in this field of research (H. B. Tukey, F. W. Went, R. M. Muir and J. van Overbeek), has, for the past two years, been drawing up a new classification to embrace all 'chemical regulators' in plants. They have rightly appreciated that the system should be of world-wide application and have invited comment on their draft scheme from plant physiologists in Great Britain. It is hoped that their final recommendations will be universally acceptable. Their task is no light one since, for example, there are some who might even oppose the use of the term 'regulator' for the many compounds that merely act as cell poisons albeit below the lethal threshold. However, when finally framed and accepted, it should be rigidly applied by all. We must remember, however, that no matter how well it may suit our present needs it cannot be more than an interim classification, and will need further revision as we increase and deepen our knowledge of the exact function and mode of action of these compounds in cell and tissue.

Water Problems in Dutch Agriculture

A LECTURE entitled "Lack of Water in a Land of Water", delivered in the international language under the auspices of the British Esperantist Scientific Association, was given by Dr. G. F. Makkink, of the Central Institute for Agricultural Research, Wageningen, on October 21 at University College, London. Dr. Makkink dealt with the problems facing agriculture in the Netherlands as a result of low rainfall combined with the excessive porosity of the soil and also as a result of the ingress of salt water. This latter factor occurs not only by seepage through the dykes but also at the sea-locks and (in dry seasons) by penetration of salt water up the estuaries. He stated, for example, that the sea-locks at Amsterdam admit daily 21×10^9 kgm. of salt into the Zuider Zee, and that during a dry season 24×10^7 kgm. of salt may enter the estuaries daily and not return; during 1949 salt water penetrated 45 km. up the Waal River and threatened the economy of important areas. Dr. Makkink concluded by outlining the ambitious programme of works which is being undertaken not only to reclaim the land out to the arc of the Frisian Islands but also partially to divert the Rhine waters into the Zuider Zee and thus form a huge reservoir of fresh water for agriculture and for use in the battle against the intrusions of sea water.

National Central Library, London: Report for 1951–52

THE thirty-sixth annual report of the executive committee of the National Central Library, London, covers the year ended February 29, 1952 (pp. 22; published by the Library), and records an increase of the Treasury grant-in-aid from £25,000 to £27,250 for 1951–52; of this, £1,000 was to compensate for the discontinuance of the Carnegie United Kingdom Trust's contribution. Contributions from libraries of all types, adult class organizations and individuals increased by 40 per cent to £5,210. The Carnegie United Kingdom Trust has agreed to the merging in the Library's general account of the separate fund for the Union Catalogue of Periodicals in University Libraries. Total issues of books from or through the Library increased from 94,220 during 1950–51 to 98,308; for the Scottish Central Library the corresponding figures are 12,616 and 15,708, and for the Irish Central Library for Students, 11,959 and 12,089. Total applications increased by 9·3 per cent, and 69·37 per cent were dealt with successfully, compared with 65·3 per cent during 1950–51. Issues to university libraries increased by 26·09 per cent, and those to outlier libraries, libraries of government departments, industrial and research organizations, and educational and cultural bodies also increased. University libraries lent 38,962 volumes under the national system. Loans made to foreign libraries remained at a high level (1,589 books to thirty-seven countries); but books borrowed from foreign libraries increased from 584 to 885 books from eighteen countries. The report refers to the need for extra funds for union cataloguing and the development of the outlier library system, as well as to progress in the union cataloguing of Russian books and periodicals available in Britain, and to the increased activities of the British National Book Centre in re-allocating 'unwanted' books and periodicals between British libraries and between libraries in Britain and those abroad. The reconstructed building of the National Central Library was opened by the Earl of Elgin in June 1952.

Physics of Particle-Size Analysis: Conference in Nottingham

THE Institute of Physics is arranging a conference on "The Physics of Particle-Size Analysis", to be held in the University of Nottingham during April 6–9, 1954. It is anticipated that the various sessions will cover not only such fundamental physical processes as the fluid dynamics and the optics of particles and systems of particles, but also accounts of other phenomena encountered in particle-size analysis such as the aggregation and dispersion of particles in a fluid. Arrangements will be made also for a discussion on automatic methods of counting and

sizing, to which great attention is being given at the present time. Although the conference will be primarily concerned with the physical principles of particle-size analysis, the development of new instruments and their use will receive attention, particular interest being attached to the systematic comparison of different methods of particle-size analysis. Papers describing original work are invited for reading and discussion at the conference, and synopses of such contributions should be sent before February 3 to the honorary secretary of the conference, Mr. R. L. Brown, at the Institute of Physics, 47 Belgrave Square, London, S.W.1.

Static Electrification: Conference in London

The Institute of Physics has arranged a conference on static electrification, which will be held at Bedford College, London, during March 25–27. Prof. F. A. Vick, of the University College of North Staffordshire, Stoke-on-Trent, will give the opening lecture, and the other sessions will each take the form of an introductory survey, followed by specialized papers and discussion. The introductory surveys will be given by Dr. P. S. Henry (general principles of the generation and dissipation of static electricity), Mr. E. S. Shire (electrostatic machines) and Mr. H. W. Swann (harmful static electrification). The more specialized papers will be available as pre-prints to those attending the conference, and the proceedings of the conference will later be published by the Institute. Further information can be obtained from the conference secretary, Mr. N. Clarke, at the Institute of Physics, 47 Belgrave Square, London, S.W.1.

University of London

The title of reader in the University of London has been conferred on the following: Dr. N. A. Barnicot, in physical anthropology, in respect of the post held by him at University College; and Dr. J. M. Coulson, in chemical engineering, in respect of the post held by him at the Imperial College of Science and Technology. The degree of D.Sc. has been conferred on Mr. Harold Barnes.

Announcements

M. Jules Baillaud, honorary director of the Pic du Midi Observatory and honorary astronomer of the Paris Observatory, has been elected a member of the Astronomy Section of the Paris Academy of Sciences in succession to the late B. Lyot.

On the occasion of his retirement from the post of research professor in agriculture in the University of Sydney, Prof. W. L. Waterhouse has been elected an honorary life member of the Royal Agricultural Society of New South Wales, in recognition of his outstanding investigations on cereals.

Dr. F. A. Fox, formerly deputy director of the British Welding Research Association, has been appointed superintending scientist in charge of the Chemical and Physical Research Laboratories, Australian Government Department of Supply, Maribyrong, Melbourne.

The following have been appointed to senior lectureships in the University of Sheffield: Dr. J. S. D. Bacon (biochemistry) and D. R. Wood (pharmacology).

Mr. P. Arthur Wells, deputy secretary of the Royal Sanitary Institute, has been appointed secretary of the Institute in succession to Dr. J. W. Dudley Robinson, who has recently retired (see *Nature*, October 25, 1952, p. 693). Mr. Wells also becomes secretary of the Royal Sanitary Institute and Sanitary Inspectors Examination Joint Board and secretary of the National Nursery Examination Board. Previously he has been director of education to the International Wool Secretariat and general secretary of the Society of Dyers and Colourists.

The Scottish Branch of the Science Masters' Association will hold its annual meeting at the Heriot-Watt College, Edinburgh, during April 7–10, with the principal of the College, Dr. H. B. Nisbet, as president. Other speakers will include Prof. G. F. Marrian, Dr. Neil Campbell, Dr. D. B. McIntyre, R. M. Sillitto, N. G. Matthews, G. Barclay and W. W. Fulton. Visits will be arranged to various places of scientific interest in the neighbourhood, and there will be exhibitions by members of the Association, publishers and manufacturers of scientific apparatus. Further details can be obtained from the organizing secretary, J. Turpie, Trinity Academy, Edinburgh 6.

A joint meeting of the Hospital Physicists' Association and the Industrial Radiology Group of the Institute of Physics is to be held at the Royal Institution, Albemarle Street, London, S.W.1, on January 16, at 7 p.m., and January 17, at 9.30 a.m., to discuss "Radiation Protection". Particulars can be obtained from the joint honorary secretary of the Industrial Radiology Group of the Institute of Physics, B. R. Byrne, Railway Executive, Research Department, Ashford Works, Kent.

The Aslib Aeronautical Group of technical librarians and information officers serving the aircraft industry will hold its second annual conference at the College of Aeronautics, Cranfield, during March 27–30. Technicians and librarians from Europe, America and the British Commonwealth will be contributing papers, and all who are interested in promoting the efficient exchange of aeronautical information are welcome to attend. Further information can be obtained from the secretary of the Group, Mr. C. W. Cleverdon, College of Aeronautics, Cranfield, Bletchley, Bucks.

A David Anderson-Berry Silver-Gilt Medal and a sum of £100 is being offered by the Royal Society of Edinburgh to the person who, in the opinion of the Council, has recently produced the best work, published or unpublished, on the therapeutical effect of X-rays on human diseases. Applications, which should be accompanied by relevant papers on the work, must be sent to the General Secretary, Royal Society of Edinburgh, 22 George Street, Edinburgh 2, before March 31.

The Medical Research Council is offering a number of fellowships in clinical research, tenable in the United Kingdom during the academic year 1953–54, which are open to suitably qualified medical graduates who desire to prepare themselves for a career in clinical research. The fellowships will be awarded for one year in the first instance, renewable annually up to a maximum of three years, and will carry a stipend of £850 a year, with annual increments of £75. Applications must be sponsored in each case by the head of the appropriate department in the candidate's university or medical school. Application forms can be obtained from the Secretary, Medical Research Council, 38 Old Queen Street, London, S.W.1, to whom they must be returned not later than March 1.

TEACHING OF ACOUSTICS

A DISCUSSION on the teaching of acoustics, under the joint auspices of the Acoustics Group of the Physical Society and the Education Group of the Institute of Physics, was held at the offices of the Institute in London on November 19, 1952, Mr. W. West, chairman of the former Group, presiding.

Dr. R. W. B. Stephens, in introducing the subject, said that acoustics has for long been somewhat neglected in schools and universities of Great Britain. This state of affairs is unfortunate; for the study of vibrations is fundamental to the whole of physics, and acoustics is probably the best vehicle for illustrating wave motion, as it provides a means of actually observing the nature of the motion as distinct from inferring it—for example, as in the case of light. In schools, a reason for the somewhat scanty attention to the subject most probably arises from the very crowded syllabus and from the fact that, viewed from the aspect of passing the General Certificate Examination (ordinary level), it has a limited value. It has been the practice for some time for only one or two questions to be set, and these in general have been modifications on a very restricted theme, which must have brought about a tendency to limit the teaching of the subject to the consideration of the few types of questions which are likely to occur. It is evident, thought Dr. Stephens, that examiners cannot escape criticism, for in the wording of questions more attention might be directed to the physics of a problem rather than making it a problem in algebra and a substitution in a formula.

In college and university there is the tendency to restrict the teaching of acoustics and regard it perhaps somewhat as an applied subject which by modern standards puts it on a lower academic plane, compared with theoretical nuclear physics. In point of fact, however, modern acoustical theory uses all the tools of mathematical physics. The treatment of acoustics as a Cinderella subject is somewhat unfortunate, as apart from academic considerations (and these are widespread, for basic acoustic theory and techniques permeate into the fields of aeronautics, applied mechanics, light electrical engineering, rheology, etc.) there is also the impact of the subject on modern everyday life which is made increasingly evident—to mention a few examples—by the problems arising from noise and vibration in aircraft, flats, factories, etc.; design of concert halls; development of electronic musical instruments, etc.

Dr. Stephens then gave the results of a questionnaire on this subject circulated to universities by the Acoustics Group. It appears that most universities think that a course is desirable, and most do give their students a specialized course of ten to fifteen lectures. There are seven postgraduate courses in all, and a number have facilities for research.

Mr. E. Nightingale, as a schoolmaster of long experience, admitted that in schools the subject does not receive anything like the attention it deserves. This is due partly to the greatly expanding physics syllabus, and partly to the fact that many teachers are afraid of the subject unless they are musically minded. Also, one must face the fact that, in the early stages, the subject does not lend itself to practical work mainly owing to the necessity for quiet in many of the experiments. This leads to the complete exclusion of the subject at this stage and to an inadequate and sketchy treatment in the sixth form. In the old days, when 'heat, light and sound' was an examination subject for the School Certificate, acoustics received far more adequate treatment than at present.

The teaching of acoustics, continued Mr. Nightingale, can be begun informally quite early by means of a useful talk on the meaning of frequency, overtone and harmonic, illustrated by simple experiments on the piano and the violin or 'cello. There is also great scope for a series of formal lessons illustrated by simple experiments of the 'sealing wax and string' type. These can give a far better training in basic physics than any number of spectacular experiments using boxed-up apparatus of the push-button type. The mathematical theory of wave motion must be left largely to the sixth form, when the necessary mathematical equipment should be available. But the fundamental ideas of frequency, period, wavelength, the equation $V = n\lambda$, the simple treatment of resonance and beats, the dependence of quality on overtones, can all be taught in the pre-Certificate course.

Mr. Nightingale then illustrated some simple experiments within the capabilities of a secondary school and showed—on a tape record—what could be done on a piano.

Dr. E. G. Richardson pointed out that acoustics is now firmly established as a subject for special study and research in four British universities, mainly with the aid of the University Grants Committee and of certain government institutions, which are anxious to have available personnel trained in the subject. Though this is good so far as it goes, the facilities in acoustics compare unfavourably with some other countries. In both the United States and Germany there are university departments or whole institutes devoted to this subject. (In the United States a number are called applied physics, but they are really acoustics plus electronics or radio waves, and the same combinations are found in Germany.) In some other European countries there are acoustics departments attached usually to technological universities, but in other countries acoustical work is done in government institutes with but a slender attachment or none to a university faculty.

Four types of students in universities require instruction in sound. Physicists certainly do, but more restricted courses are also given to architects, electrical engineers and musicians. Until he gets into the special honours school, the physics student gets little sound, but in fifteen lectures enough can be done to prepare the student for a post in industry or to start postgraduate research. There is no doubt, said Dr. Richardson, that nowadays a student could scarcely undertake experimental research in sound without a good working knowledge of electronics. In the days of Rayleigh and Lamb, hydrodynamics was the handmaid of acoustics. The pendulum has swung too far in the direction of making acoustics a branch of radio communication, which Dr. Richardson thinks is undesirable except for electrical engineers.

In the general discussion that followed, Mr. W. A. Mercer gave details of courses he is giving to honours physicists in the University of Southampton; he divides the subject into classical and modern acoustics, devoting more time to the latter. Drs. H.

Lowry and W. H. George spoke of the difficulties of teaching sound to music students, and the latter spoke also of the new M.Sc. course in the University of London, while Mr. S. R. Humby amplified previous speakers' comments on the teaching of wave motion to sixth-form schoolboys. At the conclusion of the discussion, experiments suitable for demonstrations were inspected.

PHYSIOLOGY OF THE HOST–PARASITE RELATIONSHIP IN FUNGI AND BACTERIA

THE annual plant-pathological meeting of the British Mycological Society, which was held on October 17 in the Physics Lecture Theatre of Birkbeck College, London, took the form of a symposium on the physiological relationship of host plant and parasite. Nine papers were read dealing with various aspects of this wide problem.

Prof. W. Brown (Imperial College of Science and Technology, London), who introduced the discussion, dealt primarily with the type of facultative parasite which is relatively non-specialized and which characteristically brings about a distinct rotting and killing of the host tissue. This is probably the simplest of all types and the one most open to investigation, as the effects arising are localized to the neighbourhood of the parasite and can, to a large extent, be reproduced *in vitro*. It is logical, therefore, to begin by attempting to elucidate the mechanism of the more generalized parasites and to proceed from there to the more specialized types, as illustrated by the obligate but also by many facultative parasites.

Events which take place before the parasite has penetrated the outer wall of the host and the act of penetration itself are of considerable interest and practical importance, and the physiology of these stages could be further clarified. It is, however, when entry has taken place that the most interesting relationships develop. The tissue-destroying agents are metabolites excreted by the parasites, and, though it is not safe to ignore any of these, chief attention has been paid to pectolytic enzymes and organic acids. With some fungi, such as *Botrytis cinerea*, pectin-dissolving enzymes appear to be the sole agents. The study of this parasite and of others which act similarly, for example, *Pythium* spp., *Bacterium aroideæ*, has thus become largely enzymological, with special reference to the conditions which govern enzyme secretion, and to the detailed differences in behaviour (such as selective action on various cell walls and constituents of cell walls, relation to *p*H and to various retarding and inhibiting agents, etc.) which are shown by the pectolytic enzyme systems of various parasites and saprophytes.

The part played by contact stimulation (thigmotropism) in the physiology of obligate parasites was discussed by Dr. S. Dickinson (Cambridge). It has been shown that the latter (rusts, powdery and downy mildews) respond to a contact stimulus by division of their nuclei, such stimulation being given on contact with stomatal guard cells, cuticle of epidermis, mesophyll wall and perhaps even outer layer of the protoplast. Thigmotropism is therefore a primary factor in obligate parasitism, a view which accords with recent American work in this field. It is suggested that this particular response to contact stimulation is the chief distinguishing characteristic between obligate and facultative parasites, and that in other ways, for example nutrition, they do not materially differ.

Dr. S. E. Jacobs and Mr. A. H. Dadd (Imperial College of Science and Technology, London), dealing with the leafy-gall organism (*Corynebacterium fascians*) and its behaviour on a wide range of host plants, showed that diffusible antibiotic substances are present in seeds of some of these host species. An inverse relation was discovered between percentage of seedling infection and the degree of inhibition of the bacterium brought about by exudates from seed. The inhibitory substance, when present, could be removed by soaking the seeds, but this treatment did not lead to increased infection; it had the reverse effect, possibly because of simultaneous removal of diffusible nutrients. Extracts of crushed seeds, especially after being allowed to undergo a certain amount of bacterial decomposition, stimulated growth of the parasite and increased the pathogenicity of all pathogenic strains, but failed to stimulate non-pathogenic strains to attack the host. These effects were likewise obtained by use of various chemical substances.

Mr. J. E. Crosse (East Malling Research Station) outlined the annual cycle of the bacterial canker disease of cherry caused by *Pseudomonas morsprunorum*, an over-wintering canker phase on the bark alternating with an over-summering leaf-spot phase. Infections of the bark take place in the autumn and mainly through the scar-wounds which arise at leaf-fall. Experiments with concentrated inocula gave a much higher percentage infection of a resistant as compared with a susceptible variety than was normally encountered in the field. This disparity was traced to the fact that in the autumn the parasite was more abundant on the leaves of the susceptible than of the resistant variety. As the infective bacteria are washed down by rain, the concentration of inoculum in the infection drops is likely to be higher in the susceptible variety.

A series of inoculation experiments, carried out with a range of concentrations of inoculum and at four dates during the leaf-fall period, showed clearly that the concentration of inoculum necessary to give 50 per cent infection was higher with the resistant variety. Resistance to canker under field conditions was thus a compound of two factors, a lower prevalence of the parasite on the leaf surface and a higher threshold concentration of inoculum required for infection. As a result, the conditions necessary for successful invasion were less often realized at ports of entry on the resistant variety. Infectivity of leaf scars had also been shown to vary with the date at which inoculum was applied; but the precise relationship had not yet been worked out.

Dr. P. S. Nutman (Rothamsted Experimental Station) discussed the interaction between leguminous plants, in particular clover, and strains of the nodule-forming organism. 'Effective' or symbiotic strains produced a limited number of nodules which were large and which fixed nitrogen; 'ineffective' or parasitic strains gave nodules in abundance, but these remained small because of early degeneration of their growing-points and they did not fix nitrogen. Incompatibility between the clover plant and a bacterial strain which was normally effective was also shown in certain nutritive states of the former, and the same appearances resulted as with an

ineffective strain. Both types of nodules arose at points which were potentially the initials of side roots. Experiments on nodule and root-tip excision had furnished evidence of an inhibitory activity centred in the growing-points of root and nodule, so that in effective symbiosis the first-formed nodules tended to suppress the development of nearby nodules and lateral initials, whereas ephemeral ineffective nodules had no such effect.

Developments in fungal enzymology, most of which had relation to industrial fermentations and food technology, were reviewed by Dr. R. K. S. Wood (Imperial College of Science and Technology, London). In contrast, the enzymological aspects of parasitism had been incompletely studied. No enzyme capable of attacking cutin was known, and it was not clear whether the death of cells which followed the enzymatic maceration of cell wall was due to the enzyme or to a specific toxic substance. The various types of pectolytic enzymes, he said, are as yet not clearly defined because of incomplete knowledge of the various kinds of pectic materials present in plants. Cellulolytic and proteolytic enzymes will probably also have to be taken into account.

Dr. F. T. Last (Rothamsted Experimental Station) described the behaviour of the mildew fungus, *Erysiphe graminis*, in relation to growth of the cereal plant as modified by application of nitrogenous fertilizer. The effect of the fertilizer was to increase the relative growth-rate of the host to a maximum, after which it fell, a series of changes which was paralleled by the curve of degree of infection per unit area of leaf. Growth-rate of host and susceptibility to mildew increased with increasing doses of nitrogen, large increases in infection being shown for small changes in relative growth-rate when the latter was high, and vice versa. When the same dose of nitrogen was given to nitrogen-deficient plants of two sizes, the initially smaller plants became more susceptible to mildew.

A report was given by Miss J. M. Wright and Dr. P. W. Brian (Butterwick Laboratories of Imperial Chemical Industries, Ltd.) of the isolation from some strains of *Alternaria solani* of a product—referred to as alternaric acid—which had antifungal properties and was also markedly phytotoxic. Dilute solutions (1 p.p.m. or less), when taken up by cut shoots of tomato or potato, produced lesions in stems and leaves which were similar to those formed in natural attack by the fungus. The water-absorbing efficiency of the plant was reduced, with consequent loss of turgor and desiccation. The presence of this substance has been demonstrated in tissues invaded by the fungus. No correlation, however, was obtained between the pathogenicity of various strains and their capacity to produce this acid. Strains of *A. solani* produced a variety of toxic substances, and it would be unsafe at the moment to associate pathogenicity with any one of these to the exclusion of the others.

Finally, Mr. I. A. S. Gibson (Overseas Food Corporation, East Africa) referred to a disease of groundnuts caused by *Aspergillus niger*. Experiments carried out with five members of the group to which *A. niger* belongs showed that they covered a wide range of pathogenicity and that there was a correlation between this and their acid-producing capacity. The acid primarily concerned was oxalic acid. Growth products from pathogenic strains gave the same effects on host tissue as the appropriate concentrations of oxalic acid. Invasion of the plant by *A. niger* led to collapse and death of the cells in advance of fungal growth, thereby indicating the presence of a toxic precursor to invasion. It appeared, therefore, that oxalic acid played an important part in the establishment of this parasite in the host tissue.

W. Brown

INTERNATIONAL COMMITTEE FOR ELECTROCHEMICAL THERMODYNAMICS AND KINETICS

MEETING IN BRITAIN

THE fourth meeting of the International Committee for Electrochemical Thermodynamics and Kinetics (Comité International de Thermodynamique et de Cinétique Electrochimiques) opened in the Chemistry Department of the Imperial College of Science and Technology, London, on September 10 and continued during September 11–13 in the Department of Metallurgy, University of Cambridge. The aim of the Committee is to provide an international body of those interested in fundamental electrochemistry, especially electrode processes, and to promote contact between these workers and those interested in applied and industrial electrochemistry.

The organization of the London part of the meeting was carried out by Dr. J. O'M. Bockris and that at Cambridge by Dr. T. P. Hoar (vice-president). Among distinguished foreign visitors to the meeting were Profs. G. Charlot (Paris), H. Fischer (Berlin), K. Huber (Berne), E. Lange (Erlangen), R. Piontelli (vice-president, Milan), M. Pourbaix (secretary, Brussels), A. J. Rutgers (Ghent), A. U. Traghardt (Stockholm), G. Valensi (Poitiers), and P. van Rysselberghe (president, Oregon). Among the British electrochemists present in addition to Drs. Hoar and Bockris were Prof. W. F. K. Wynne-Jones and Drs. J. N. Agar and R. Parsons.

In London a lecture was given by Dr. Bockris on "Electrochemical Research at Imperial College", and in Cambridge a lecture by Dr. U. R. Evans entitled "Corrosion Research at Cambridge". About forty papers were presented at the meeting. P. van Rysselberghe treated the theory of polarization in terms of the thermodynamics of irreversible processes and showed how the laws between current and overpotential may be thermodynamically deduced at low current densities. Thermodynamic considerations can be of considerable application in the examination of the complex kinetic processes which occur in, for example, corrosion. The same author also showed how a consideration of the Peltier heats in concentration cells may open up a new approach to the old, but unsolved, problem of absolute electrode potentials. Difficulties preventing progress in the theory of the electric double layer were considered by J. O'M. Bockris. Among these are those connected with the inadequate definition of potential differences at phase boundaries. The independence of the capacity of the negative branch of the electrocapillary curve upon the cations present is still a difficult problem but may be explicable in terms of a model of the solvated ions in the double layer. The importance of attempts to calculate the surface potentials associated with adsorbed dipoles and electron overlap at metal solution interfaces was stressed.

H. Gerischer showed how the measurement of A.C. polarization resistance can help with the analysis of processes in metal deposition. Thus, in the case of silver ion deposition on silver from simple salt solution, it appears that the rate of the reaction is controlled by the building into the surface of the metal atoms and that discharge of the ions is rapid. Correspondingly, interesting data were presented by H. Fischer, who treated the various stages of action of an inhibitor in metal deposition in terms of the theory of crystal growth. T. P. Hoar described experiments which strongly suggest that dissolution of an anode which is undergoing polishing or brightening occurs through a compact solid film on the surface and that this film dissolves its outer surface as fast as it is formed at the metal/solution interface. This account summarized the points in favour of a theory which probably represents the essential solution of the long-standing problem of electropolishing. W. F. Franck showed that the polarization resistance measured at an attackable electrode suddenly changes at the equivalence point of a titration and illustrated how this property could be used in analysis.

Among other subjects treated were: the definition of a chemical potential in an electrochemical system; the influence of the electronic structure of a metal on the rate of an electrochemical reaction taking place at its surface; cathodic reduction of oxygen to hydrogen peroxide; the inhibition of corrosion; and the electrokinetic potentials of sols in silver iodide. The papers and the discussion material will appear in the *Comptes rendus* of the Committee, which is published yearly.

The Commission on Electrochemical Definitions and Nomenclature (J. O'M. Bockris, R. Defay, E. Lange, R. Piontelli, P. van Rysselberghe and G. Valensi) held several sessions in London and Cambridge and will publish a second report in the *Comptes rendus* for 1952. A Commission on Experimental Methods in Electrode Processes was formed, consisting of J. O'M. Bockris, H. Gerischer, R. Gauguin, R. Piontelli and G. Valensi, and will make its first report in 1953. The total attendance at the meeting was about seventy. The next meeting will be held at Stockholm in July of this year.

THE TIAN–CALVET MICROCALORIMETER IN SEED GERMINATION STUDIES

PROF. H. PRAT, of the Institute of Biology, University of Montreal, has described some preliminary investigations of thermogenesis in germinating seeds of various cereals, flax, tomato, etc., using the new Tian–Calvet calorimeter (*Canad. J. Bot.*, 30, 4, 379; 1952). The use and advantages of the new instrument are indicated.

The type of thermogenic curve obtained from the germination of wheat seeds seems likely to have a general application. Immediately upon the contact between the dry seed and water there is a quick, then a falling off, and then a more slowly developing, production of heat; that is, the curve shows a steep rise and fall and then a slow steady rise. The initial phase of rapid rise and fall in the curve is common to both living and dead seed and is ascribed to physico-chemical thermogenesis. The ensuing phase of depression may be endothermic or weakly exothermic. The third phase of steadily increasing heat production, which corresponds to the onset of growth, with its concomitant respiration, is described as biological thermogenesis.

By using the new microcalorimeter it is possible to determine with considerable accuracy the effects on the thermogenic curve of such factors as temperature, dehydration of seed, ageing of seed, and additions of substances to the soaking water; for example, biological thermogenesis is increased by indoleacetic acid at low concentrations and diminished by alcohol and iron sulphate. A comparison of the thermogenetic responses of different seeds opens a wide field of study: the interesting and suggestive preliminary data which are given seem likely to have both an academic and a practical importance.

RECENT MARINE BIOLOGY

THE first two numbers of Vol. 31 of the *Journal of the Marine Biological Association* cover a wide field in the studies of the seas and their inhabitants.

Three papers are further instalments in their respective series. Dr. G. P. Wells contributes his sixth paper on *Arenicola*, dealing with the proboscis of three species and its mode of action, in which there are beautiful photographs of both the exterior and interior of the proboscis. Dr. H. G. Vevers's fourth article on the biology of *Asterias rubens* describes the variation in the sex ratio; the highest percentage of females occurred in the period March–June and the lowest during January–February, and he found no trace of hermaphroditism. In his third paper on *Chætopterus variopedatus*, Dr. J. A. C. Nicol discusses factors affecting the light response. Stimulation of the photogenic glands occurs through their nerve fibres; but augmentation of the response takes place locally in the glandular tissue itself. There is, however, a process of central facilitation in the nerve cord, most apparent in the posterior region of the body. The luminescent reaction is a triggered response which can be produced by a single stimulus.

There are three papers on Ascidians. Dr. R. H. Millar worked out the annual growth and reproductive cycle in *Diplosoma listerianum*, *Ciona intestinalis*, *Ascidiella aspersa* and *Botryllus schlosseri*. Each species behaved as an annual, settling as a larva, breeding and dying within a period of from twelve to eighteen months; breeding occurred in summer. Miss P. Kott, in a résumé of certain compound Ascidians of the Plymouth area, with a description of two new species, considers that *Aplidium nordmanni* and *A. proliferum* are forms of the same species, and that Giard's *A. densum* is synonymous with the latter; Berrill (1950) regards them as distinct species. Obviously we require comparative details of specimens from different areas around the British coasts before lumpers or splitters are accepted as authorities.

Dr. J. S. Alexandrowicz has been able to complete his investigation, begun in 1931, of the innervation of the heart of *Ligia oceanica*. He found three systems of nerve elements—six neurons constituting a local system, a pair of nerves connecting this with the central system, and the nerves of the arterial valves; the alary muscles have their own innervation.

Dr. W. Wieser carried out an intensive population count of the microfauna inhabiting single tufts of seaweeds on the rocks below the Plymouth Labor-

atory. He took samples under water in the infra-littoral and littoral zones during high water, by diving, "using nothing but glasses, flippers and a belt with pieces of lead fixed to it". Eight weeds were chosen, and one sample of *Gelidium corneum* yielded the astonishing number of 2,818 animals per gram of dry weed, including 600 Nematodes and 1,864 specimens of *Lasæa rubra*. Observations under water, using a modified frogman apparatus, were also made by Mr. R. Bainbridge, who describes the swimming habits of *Calanus* and *Sagitta*.

The necessity to control the bacterial contamination of mould-free phytoplankton cultures led Mr. C. P. Spencer to experiment with the antibiotics penicillin and streptomycin, the former being the more effective in keeping the culture pure. Miss B. Ross studied the changes in chemical composition at various ages of *Himanthalia elongata*, and found that any estimate of the chemical composition at different seasons should be correlated with the size of the vegetative buttons and thongs. Cultures of sixteen species of the smaller marine algæ, including seven flagellates, were prepared by Mr. R. W. Butcher, whose paper is illustrated by coloured figures of all the species. Finally, the first number of Vol. 31 concludes with an interesting account by Dr. D. P. Wilson of the aquarium and sea-water circulatory system at the Plymouth Laboratory.

In the second number, Dr. H. G. Vevers describes improvements in his apparatus for photographing the sea floor, whereby the camera is set at 1 m. from the ground and records an area of 50 cm. × 50 cm., thus producing better definition. As the result of his surveys, Dr. Vevers estimates that near Looe there is a population of *Ophiothrix fragilis* at least two miles long and half a mile broad, at a density of 392,000 per acre. North-west of the Eddystone the population is even greater and reaches 1·3 million per acre. In both cases, tidal streams probably bring suspended food to the crowded beds, and the scavenging work of these brittle stars, whether of detritus or of sinking matter, must be considerable.

Dr. R. B. Pike has worked on the biology of the prawn *Pandalus bonnieri*, which is a dicecious species living in deep water. Breeding occurs from the end of October for from six to eight weeks, and the young leave the berried female from February to April in the following year, metamorphosing in June. Sexual maturity is reached in eighteen months. The maximum life-span is four years; but few live beyond three years in the Clyde area.

Dr. J. S. Alexandrowicz studied the muscle receptor organs in the Paguridæ, and Mr. Graham Hoyle the response mechanism in the Ascidians, *Phallusia mammillata* and *Ascidiella aspersa*. Prof. J. E. Harris has kept records of the breeding condition of dogfish supplied to the University of Bristol from the Ilfracombe area, and concludes that spawning starts in November and continues until July. A Fulbright scholar from Miami, Mr. R. F. Hutton, has named a cercaria from the cockle, *Cercaria fulbrighti*, and gives a full description of it and other parasites from this lamellibranch.

To the biological indicators of water movements in the English Channel (*Sagitta* and *Muggiæa* spp.), Dr. L. H. N. Cooper suggests adding the boar fish, *Capros aper* (L.), the occurrence of which coincides with that of *Muggiæa kochi*, indicating movement of water from the south-west area of the continental slope towards Plymouth, after a period of strong south-west winds succeeded by calm weather. Hydrographical observations are recorded by Dr. W. R. G. Atkins and Miss P. Jenkins, and on the reaction of marine animals to ultra-violet light in conjunction with echo sounders by R. E. Craig and I. G. Baxter, who hope that further work will produce results of practical importance to the fishing industry.

In their first paper in a series on the vitamin A and carotenoid content of invertebrates, Mr. L. R. Fisher and Drs. S. K. Kon and S. Y. Thompson describe an investigation of the various Crustacea from the British coasts, particularly the Euphausiids, *Meganyctiphanes norvegica* and *Euphausia superba*, the krill upon which some whales feed. These contained large quantities of vitamin A, 90 per cent of which was in their large eyes, together with a high proportion of their astaxanthin. No carotene was present. The vitamin A concentration was lower in decapods, absent in the copepod *Calanus finmarchicus*, amphipods, isopods and *Cladocera*. By consuming krill, a baleen whale may take in one ton of vitamin A, to be stored in the liver, which would yield about 2,000,000 I.U.

The volume ends with the report of the Council of the Marine Biological Association. It is pleasant to note that for the first time the Association will be able to have a vessel specially built as a research ship. Membership has increased by 47 to 659.

N. B. Eales

PATTERNS OF SPRING MIGRATION

In 1950 and 1951 the British bird observatories exchanged information about the occurrences of selected species of birds. A study of this collated information by R. K. Cornwallis appears to throw some light on the pattern of migration to and through the British Isles in spring (*British Birds*, **45**, No. 9; September 1952).

The simple conception of this pattern of spring migration is one of a south-to-north movement. The birds, it is assumed, enter England at points along the south coast and proceed northwards until they either reach their breeding-grounds in Britain, or, if they do not remain to breed, strike north-west to Iceland or north-east to Scandinavia from our northern coasts. This is often assumed in ornithological writings to be what happens, though the subject is a neglected one.

Not all the facts, however, appear to fit this simple pattern. For example, certain birds which breed in Scandinavia and occur in Britain both as summer residents and as passage migrants were recorded on spring migration in 1950 in greater numbers at the more northerly bird observatories, the numbers decreasing regularly with each more southerly observatory in turn (pied flycatcher, garden warbler, lesser whitethroat, common redstart).

It is common, too, when waves of birds are recorded at the east-coast observatories, for these to occur on approximately the same date at all of them and not progressively later at the more northerly stations (redstarts, pied flycatchers, fieldfares and ring ouzels). Moreover, the greatest numbers of some birds are often observed, particularly at east-coast stations, on dates when British breeding birds of the same species have already started nesting, even when the breeding-ground lies farther north than the observatory.

A fourth fact is that at Gibraltar Point the direction of diurnal migration in the spring, as well as in the

autumn, is almost invariably to the south-west. At Cley it is from east to west. In north Lincolnshire it is more orthodox, being north-west along the south bank of the Humber, but at Spurn both northward and southward movements are seen.

The most likely explanation of these facts seem to be that, as well as receiving migrants in accordance with the simple south–north pattern, the British Isles also receive "drift-migrants" which, aiming for their Scandinavian breeding-grounds, are drifted westwards across the North Sea by the wind.

It is likely that drift of this kind affects nocturnal migrants much more than it does diurnal ones, for they, presumably, must rely for navigation principally on "preferred direction" and not on coastal and other "guiding-lines", and are therefore more likely to be sent off-course by the invisible forces of wind-drift. The directions of diurnal migration at Cley and Gibraltar Point, however, seem to indicate that some diurnal migrants are also subject to drift of the same kind.

Drift-migration of this type explains the coincidence of dates on which "waves" of birds are recorded as reaching the east coast, and also explains the movements after British breeding birds are already nesting; these later movements are composed of quite different, probably Scandinavian, breeding populations.

T. H. Hawkins

AFFINITY: A NEW GENETIC PHENOMENON IN THE HOUSE MOUSE

Evidence from Distant Crosses

It is generally assumed that at the first meiotic division the orientation of each bivalent towards the poles of the cell is at random, and consequently that (apart from viability disturbances) genetic linkage is the basis of all departures from Mendel's Law of Independent Assortment. Exceptions to random orientation are known in, for example, *Sciara*[1,2], certain scale insects[3], the Ascomycete *Bombardia lunata*[4], and *Drosophila melanogaster*[5]. Analogous phenomena in Heteroptera have been described and discussed by Dr. C. D. Darlington[6].

In the last two cases, the region of the chromosome responsible for the preferential orientation was shown to be the neighbourhood of the centromere, as might in general be expected, since it is the centromere which normally directs the orientation and movement of the chromosome on the spindle.

If the respective centromeres of more than one chromosome simultaneously show non-random segregation, the loci lying on *different* chromosomes may appear to belong to the same linkage group. The strength of the apparent linkages will depend both on the degree of preferential orientation of the centromeres and on the strength of the true linkages between the loci concerned and their centromeres. Such quasi-linkages will not show the type of arithmetical regularities which characterize true linkage and which reflect the linear order of the linked loci on the same chromosome.

The purpose of this communication is to suggest an interpretation along these lines of anomalous segregation ratios which were obtained by various workers many years ago from distant crosses in the mouse. It is hoped that the hypothesis advanced here will, if confirmed, be of some genetic and evolutionary interest.

The main body of data to be considered resulted from a cross performed by Gates[7] between a male 'Japanese' waltzer (a domesticated variety of *Mus bactrianus*) and a female European laboratory mouse (*Mus musculus*). The phenotypic frequencies in the backcross progeny departed strikingly from Mendelian expectations, as can be seen from the accompanying table. In addition to the marked loci shown, segregation also occurred at the pink-eye locus. But since it made no contribution to the statistical disturbance, the data are presented here after combining the pink-eyed with the non-pink-eyed classes.

Phenotypic ratios derived by Gates from an *M. musculus* × *M. bactrianus* cross

First cross: ♀ $\frac{pdb++}{pdb++} \times \delta\ \frac{+++sv}{+++sv}$

Backcross: F_1 ♀♀ $\frac{pdb++}{+++sv} \times F_1 \delta\delta\ \frac{pdbsv}{+dbsv}$

Backcross progeny				Comparison of observation with expectation calculated on the basis of 'polar' affinity. Complementary genotypes added	
				Observed	Expected
$++sv$	117	$db++$	86	203	199·7
$++s+$	77	$db+v$	85	162	176·6
$+++v$	85	$dbs+$	83	168	172·8
$++++$	81	$dbsv$	88	169	152·9
$+bsv$	77	$d+++$	90	167	167·0
$+bs+$	73	$d++v$	86	159	147·7
$+b+v$	79	$d+s+$	67	146	144·5
$+b++$	59	$d+sv$	56	115	127·8
				1,289	1,289·0

d = dilute, b = brown, s = pied, v = waltzing

The fit to expectation is very poor. $\chi^2_{(15)}$ is 36·170, and if we eliminate the eight degrees of freedom relating to the equivalence of complementary genotypes, we have $\chi^2_{(7)} = 26{\cdot}432$ ($P < 0{\cdot}001$). Gates noted that the ratios were disturbed and also that the single-factor ratios were good. He directed attention to the marked excess of the *bactrianus* combination of characters, and as an interpretation he postulated an "association system"—"a definite tendency on the part of the chromosomes to associate together according to parental grouping, thus distorting the theoretical proportions". His meaning is not entirely clear for the following reasons: (1) the parental chromosomes no longer exist as such after crossing-over; each chromosome enters a gamete as a patchwork of material derived from both parents; (2) he remarks, "The chromosomes of the female parent, as representative of the fancy mouse, do not seem to group together as strongly as those of the Japanese parent . . .". This casts doubt on whether he intended to refer to meiotic phenomena at all; and (3) earlier work to which he refers as exemplifying "association systems" in fact relates to superior viability of non-recombinant gametes in species hybrids, and not to the mode of gamete formation.

Gates's phrase 'association system' did, however, suggest the present hypothesis, which may, in fact, be no more than a development of his intended meaning. It is that, at the first meiotic division in the hybrid, *musculus* centromeres tend to go to one pole and *bactrianus* centromeres to the other. Sir Ronald Fisher has suggested to me that the term 'affinity' be adopted for this phenomenon. It could result from an attraction of centromeres of like origin either for each other (which I shall term 'mutual affinity'), or for some polar element of the cell ('polar affinity').

On the hypothesis of 'polar affinity', the best-fitting assumptions are that the segregation of *d* is completely polarized, and that *b*, *s* and *v* are polarized with intensities calculable from their respective frequencies of segregating to the same pole as *d*, namely, 54·46 per cent, 53·61 per cent and 53·06 per cent. On the basis of other work[8], these loci have been assigned to separate linkage groups, and their mutual relations in Gates's data are incompatible with true linkage.

The expected numbers calculated on these assumptions are shown in the table. χ^2 measuring goodness of fit is 14·013 and has eleven degrees of freedom, four having been used in the estimation of four parameters. If we eliminate the eight degrees of freedom corresponding to the equivalence of complementary genotypes, we have $\chi^2_{(3)} = 5{\cdot}274$ $(0{\cdot}2 > P > 0{\cdot}1)$. Hence the fit is judged to be satisfactory. An even closer concordance between observation and expectation can be attained if the affinity is assumed to be of the 'mutual' type. Indeed, a simplified model of mutual affinity can be devised which will reduce the $\chi^2_{(3)}$ of 26·432 $(P < 0{\cdot}001)$ to a $\chi^2_{(3)}$ of 2·406 $(P > 0{\cdot}8)$.

There are two other bodies of data derived from *M. musculus* × *M. bactrianus* crosses which are suitable for testing this hypothesis[9,10]. In both, the wild variety of *M. bactrianus* was used. Since Gates's data indicate that *d* is very close to its own centromere, the most relevant and informative quantities are the frequencies of recombination between *d* and the other segregating genes.

It turns out that the segregations of *d* with *a* and with sex are compatible with independent assortment; but, as expected, apparent linkage between *d* and *b* appears in these data too. The actual recombination frequencies, however, exhibit some remarkable incongruities. Female hybrids of the *M. musculus* × wild *M. bactrianus* cross show significantly more recombination (53·3 ± 2·3 per cent, from Green's data) both than female *M. musculus* × Japanese waltzer hybrids (45·5 ± 1·4 per cent, from Gates's data), and than their male *M. musculus* × wild *M. bactrianus* counterparts (40·8 ± 2·4 per cent, from Little's and Green's data combined). However, sex differences in crossing-over are not unusual in the mouse, and it is a commonplace that chiasma formation is suppressed in distant crosses to a greater or less extent according to the degree of genetic disparity between the parental forms. The Japanese waltzer has been split off from the wild form for many centuries, a period of time in which considerable genetic divergence between the two groups could occur.

Dr. C. D. Darlington has suggested to me a possible variant interpretation of these data according to which the Asiatic and European forms differ by a reciprocal translocation. But it is likely that such an interchange would be associated with substantially reduced fertility, at least in the female hybrids, in contrast with the exceptionally high fertility reported by both Gates and Green.

It is intended to publish in due course a full account of the theoretical deductions from the *M. musculus* × *M. bactrianus* crosses, together with a discussion of the evolutionary significance and possible physical basis of the phenomenon. In spite of repeated efforts, it has not yet been possible to obtain stocks from which to produce hybrid material suitable for applying cytological and further genetic tests to this theory.

I am indebted to many people for criticisms and suggestions, especially to Dr. A. R. G. Owen and Mr. N. T. J. Bailey for statistical help and advice, to Sir Ronald Fisher, Prof. J. B. S. Haldane and Dr. C. D. Darlington for helpful discussions, and to Dr. E. B. Ford for his continual interest and encouragement, and for his strenuous attempts, as yet unhappily unrewarded, to obtain live specimens of *M. bactrianus* for me. I am in receipt of a research training grant from the Medical Research Council, and I wish also to express my gratitude to the Agricultural Research Council for the provision of facilities.

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Evidence from within Laboratory Stocks

OVER a period of a few years, I have observed, in data produced for other purposes, an association between *W* (dominant pied) on chromosome III, and *Sd* and *fi* (Danforth's short tail and fidget) on chromosome V of the house mouse. Sir Ronald Fisher, on receiving privately from Mr. Donald Michie, of the Genetics Laboratory, Oxford, his interpretation of the findings of Gates[1] and others, realized that here might lie an explanation of this association, and proposed the term 'affinity' for the phenomenon.

Affinity, or an effective attraction between like centromeres, is proposed by Michie as producing the quasi-linkages observed by Gates and others in back-cross progeny from the F_1 of crosses between two sub-species of *Mus*. (It is not intended to discuss here whether this attraction is direct—between centromeres only, or indirect—between centromeres and differentiated poles of the dividing cell.) That such an attraction of centromeres might also operate within a colony of a species (namely, *Mus musculus*) now became apparent to Sir Ronald Fisher and myself. The principle of affinity within a species, if it can be established as of more or less general application among plants and animals, has some important aspects. One is that, without the use of sub-specific hybrids, which has several disadvantages, it facilitates both identification of centromere markers and calculation of the positions of centromeres on their chromosomes. Affinity observable within a species has, also, an evolutionary significance.

In order to establish this principle, I have planned a method of manipulating the genetic material available, involving chromosomes III and V, in order to show various kinds of segregation of their centromeres, and in order to calculate the position of the centromere on chromosome V. I have also searched for and found, from experiments designed for other

purposes, data which appear to show segregation of centromeres in other chromosomes.

A satisfactory demonstration of affinity, from unprepared material, is not easily made. There are several reasons for this. One is the expected disappearance of quasi-linkage on inbreeding, or on using stocks of which the centromere genotype has not been tested or fixed by inbreeding. Another is the difficulty of distinguishing not only quasi-linkage of high recombination value from independence, but also of distinguishing these two from reversal of the linkage, which can theoretically occur; from unprepared material it is not always possible to calculate which of these kinds of quasi-linkage will occur, or to calculate exactly their expected frequencies. Reversal can be defined (in the terms of real linkage) as the segregation in one linkage phase of centromere markers known to be ancestrally in the opposite phase. It gives a formal linkage value greater than 50 per cent. This value is always $1-y$, where y is observed in the absence of reversal. An example is given below. A third reason is the difficulty of repeating striking results.

It is obviously desirable to have material from which repetitions can be made by workers who may wish to confirm my results. The best material, namely, segregating inbred lines and linkage groups, is fortunately available or is being constructed in this department as part of Sir Ronald Fisher's plan for the systematic detection of linkage and for accurate mapping. At his suggestion I have made up crosses between inbred lines and backcrossed to multiple recessives, in order both to discover new quasi-linkages, and to recognize them in material from which they can at any time be reproduced. As a result of this work, which is still in progress, a quasi-linkage has been obtained sufficiently striking to seem worthy of publication. Using the convention of real linkage, this may be represented as follows:

Sd ex line 4 × *Ca* (Caracul) ex line 10

One $\frac{Sd+}{+Ca}$ male × several $\frac{++}{++}$ females

	++	*Ca*	*Sd*	*CaSd*	Total	Recomb. value	Linkage χ^2
fz	18	10	6	13	47	65·96%	4·7872
+	23	10	8	13	54	66·67%	6·0000
Total	41	20	14	26	101	66·34%	10·7872

The datum is divided into *fz* (fuzzy) and 'not *fz*', because this factor is also segregating as a backcross and, although fuzzy itself is quite unmistakable, *Ca* presents some difficulty of classification in the presence of *fz*. However, the two sets of data manifestly agree well.

A new cross between lines 4 and 10 has been set up in the hope that these lines are sufficiently inbred to allow repetition of these results.

It is encouraging, although not unexpected, that similar, if less striking, data have already been reported. Dunn, Gluecksohn-Schoenheimer and Bryson[2] give the following table:

Cross	++	*Ca*	*Sd*	*CaSd*
+/*Sd* +/*Ca* × ++	50	33	35	43

The authors do not say from which parent the dominants of the double heterozygote came, but it seems probable that they were in repulsion, since *Sd* (which is here described for the first time) is not stated as occurring in a Caracul stock. The recombination value calculable on these data is 57·76 per cent, and the linkage χ^2 is formally just significant at 3·8820. Dunn and his associates draw no conclusion from the data other than that "It (*Sd*) is probably not linked with Caracul (*Ca*)".

That the association between *Sd* and *Ca* apparent in these two bodies of data is not easily interpreted as real linkage, even on the basis of unusually strong interference, is indicated by the fact that another, comparatively large, body of repulsion data from this department shows almost perfect independence of *Sd* and *Ca*:

Cross	++	*Ca*	*Sd*	*CaSd*	Total	Recomb. value	Linkage χ^2
$\frac{Sd+}{+Ca}$ × ++	60	65	56	62	243	50·21%	0·0029

These results are in good accord with the theory of affinity.

A fuller account of observation and theory will be submitted later to *Heredity*.

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ENZYMATIC BREAKDOWN AND SYNTHESIS OF ACETOACETATE

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Acetoacetate and other β-keto-acids can contribute acetyl groups for citrate synthesis or sulphanilamide acetylation. Thus, cleavage of the β-keto-acid must yield acetyl coenzyme A. In pigeon liver[1] and yeast extracts[2] the reaction requires the presence of adenosine triphosphate and coenzyme A (CoA).

The formation of acetyl coenzyme A has now been directly demonstrated in extracts of pig kidney incubated with acetoacetate, adenosine triphosphate, and coenzyme A, in the presence of magnesium ions (Mg^{++}) and reduced glutathione. In all these cases, acetyl coenzyme A may be formed via the following reactions:

$$\text{Acetoacetate} + \text{CoA} + \text{ATP} \rightleftharpoons \text{acetoacetyl CoA} + \text{adenosine-5-phosphate} + \text{pyrophosphate} \quad (1)$$

$$\text{Acetoacetyl CoA} + \text{CoA} \rightleftharpoons 2\ \text{acetyl CoA} \quad (2)$$

Reaction 1 would be analogous to the adenosine triphosphate–coenzyme A–acetate reaction, the mechanism of which has recently been elucidated by Lipmann and his collaborators[3].

As pigeon liver extracts can also catalyse the synthesis of acetoacetate[4] by a reaction involving two molecules of acetyl coenzyme A[5], it is possible that such synthesis in liver occurs by a reversal of reaction 2 (cf. Lynen *et al.*[6]) coupled with the action of a specific acetoacetyl coenzyme A deacylase (reaction 3):

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$$\text{Acetoacetyl CoA} + H_2O \rightarrow \text{acetoacetate} + \text{CoA} \quad (3)$$

The acetoacetate synthesizing system has been purified seven-fold from ox liver extract using an assay (cf. Table 3) with acetyl phosphate, coenzyme A, and phosphotransacetylase as a source of acetyl coenzyme A[5]. The partially purified system synthesizes acetoacetate from acetyl coenzyme A (Table 1). It does not, however, cleave acetoacetate, in the presence of adenosine triphosphate and coenzyme A, to acetyl coenzyme A, and hence does not catalyse reaction (1)

TABLE 1. ACETOACETATE SYNTHESIS FROM ACETYL COENZYME A
The complete system contained tris(hydroxymethyl)aminomethane–hydrochloric acid buffer, *p*H 8·1, 30 micromoles; magnesium chloride, 8 micromoles; acetyl coenzyme A, 2·9 micromoles; ox liver ethanol fraction (27 mgm. protein). Volume, 3·0 ml.; temperature, 25°. The yield of acetoacetate is only 40 per cent of that expected from the liberation of sulphydryl (that is, coenzyme A), presumably as a result of acetyl coenzyme A deacylase activity. Acetyl coenzyme A was prepared chemically by the method of Wilson (ref. 7)

Time (min.)	Sulphydryl liberation (micromoles)	Acetoacetate synthesis (micromoles)
0	0	0
40	3·20	0·64

Another mechanism of formation of acetoacetyl coenzyme A has been suggested by experiments with enzyme preparations obtained from pig heart extracts by fractionation with ammonium sulphate and ethanol. These experiments, in which the formation of acetyl coenzyme A was followed through its reaction with oxalacetate to form citrate in the presence of an excess of condensing enzyme[8], support the occurrence in heart of the following sequence of reactions. (Similar reactions have been postulated independently by D. E. Green and co-workers[9].)

$$\text{Succinate} + \text{CoA} + \text{ATP} \rightleftharpoons \text{succinyl CoA} + \text{ADP} + \text{P} \quad (4a)$$

$$\text{or } \alpha\text{-Ketoglutarate} + \text{CoA} + \text{DPN}^+ \rightarrow \text{succinyl CoA} + CO_2 + \text{DPNH} + H^+ \quad (4b)$$

$$\text{Succinyl CoA} + \text{acetoacetate} \rightleftharpoons \text{succinate} + \text{acetoacetyl CoA} \quad (5)$$

$$\text{Acetoacetyl CoA} + \text{CoA} \rightleftharpoons 2 \text{ acetyl CoA} \quad (6)$$

$$2 \text{ Acetyl CoA} + 2 \text{ oxalacetate} \rightleftharpoons 2 \text{ citrate} + 2 \text{ CoA} \quad (7)$$

The basic observation is that heart extracts, or the enzyme fractions therefrom, synthesize little or no citrate from acetoacetate, coenzyme A, adenosine triphosphate, and oxalacetate, unless succinate is also present. Table 2 *A* shows that, in addition to succinate, citrate synthesis from acetoacetate and oxalacetate requires coenzyme A, adenosine triphosphate, and magnesium ions. The condensing enzyme was not limiting in the enzyme fractions employed. As previously observed by others[10], it has been found that two molecules of citrate are formed for each molecule of acetoacetate disappearing. Acetoacetate can be replaced by β-ketovalerate, β-ketohexanoate and β-ketoisohexanoate, in order of decreasing activity, but not by β-ketooctanoate or β-ketoadipate (Table 2 *B*). β-Hydroxybutyrate, butyrate, hexanoate and octanoate (tested with coenzyme I and II as hydrogen acceptors) and acetate are not active in this system.

In the absence of oxalacetate, addition of stoichiometric amounts of acetoacetate, coenzyme A and adenosine triphosphate, together with magnesium

TABLE 2. CITRATE SYNTHESIS FROM ACETOACETATE AND OTHER β-KETO ACIDS
(*A*) The complete system contained tris(hydroxymethyl)aminomethane–hydrochloric acid buffer, *p*H 7·5, 100 micromoles; potassium adenosine triphosphate, 10 micromoles; coenzyme A (85 per cent pure, obtained from the Pabst Laboratories, Milwaukee, Wisconsin, through the courtesy of Dr. A. Frieden), 0·1 mgm. (about 0·1 micromole of pure coenzyme A); magnesium chloride, 8 micromoles; reduced glutathione, 10 micromoles; potassium acetoacetate, 100 micromoles; potassium succinate, 100 micromoles; potassium oxalacetate, 20 micromoles; crystalline condensing enzyme, 5 units; pig heart enzyme fraction (6 mgm. protein) obtained by fractionation with ammonium sulphate and ethanol. Volume, 1·66 ml.; incubation, 60 min. at 38°
(*B*) The complete system was the same as in (*A*) except that 100 micromoles of each β-keto-acid was added as indicated. The heart-enzyme fraction was similar to that used in (*A*) and contained 14·6 mgm. of protein

A		*B*	
Components	Citrate synthesis (micromoles)	Acetyl donor	Citrate synthesis (micromoles)
Complete system	3·18	None	0
No acetoacetate	0	Acetoacetate	5·41
No succinate	0·03	β-Ketovalerate	1·66
No adenosine triphosphate	0·05	β-Ketohexanoate	0·93
No coenzyme A	0·05	β-Ketoisohexanoate	0·26
No magnesium ions	0·04	β-Ketooctanoate	0·02
No oxalacetate	0	β-Ketoadipate	0
No condensing enzyme	3·22		

ions and a reducing agent (glutathione or hydrogen sulphide), to the heart enzyme fractions results in the accumulation of acetyl coenzyme A provided succinate is also present. The acetyl coenzyme A was identified after deproteinization by its reaction with oxalacetate, in the presence of crystalline condensing enzyme, to form citrate and by paper chromatography[11]. Also, when β-ketovalerate (or β-ketohexanoate) is incubated with the heart fractions in the presence of the complete system minus oxalacetate, and neutral hydroxylamine is added later to trap thiol esters, the formation of acetohydroxamic and propionohydroxamic acids (or acetohydroxamic and butyrohydroxamic acids) can be demonstrated by chromatographic methods[12].

Reaction 4*a* is catalysed by the system discovered by Kaufman[13] which is present in the heart fractions employed in this work. In heart acetone powder extracts, which do not contain α-ketoglutaric dehydrogenase, the succinate – coenzyme A – adenosine triphosphate system can be replaced by α-ketoglutarate, coenzyme A, and coenzyme I, in activating acetoacetate breakdown to acetyl coenzyme A, provided a purified α-ketoglutaric dehydrogenase fraction is added. α-Ketoglutaric dehydrogenase catalyses reaction 4*b*[13].

Unlike liver, heart extracts do not synthesize acetoacetate in the presence of the acetoacetate assay system. However, they synthesize appreciable amounts of acetoacetate when succinate is added (Table 3). This synthesis apparently proceeds by reversal of reactions (6) and (5) coupled with the action of a succinyl coenzyme A deacylase (reaction 8 [13]) present in the extract, thereby regenerating coenzyme A and allowing it to function catalytically.

$$\text{Succinyl CoA} + H_2O \rightarrow \text{succinate} + \text{CoA} \quad (8)$$

In some heart fractions, the yield of acetoacetate in the presence of succinate is further increased by the addition of a purified succinyl coenzyme A deacylase from heart. Indeed, succinyl coenzyme A deacylase activity is so limiting in heart fraction III (Table 3) that both succinate and deacylase fraction are required for acetoacetate synthesis.

The free energy change of reaction (6) can be estimated from the energy content of the acyl

Table 3. Acetoacetate Synthesis with Heart Enzymes
The acetoacetate assay system contained tris(hydroxymethyl)aminomethane–hydrochloric acid buffer, pH 8·1, 150 micromoles; magnesium chloride, 4 micromoles; potassium chloride, 50 micromoles; coenzyme A, 0·1 mgm., obtained from the Pabst Laboratories, Milwaukee, Wisconsin, through the courtesy of Dr. A. Frieden (about 0·1 micromole of pure coenzyme A); lithium acetyl phosphate, 50 micromoles; L-cysteine, 20 micromoles; and 10 units of a partially purified phosphotransacetylase preparation from *Strep. hæmolyticus*. Potassium succinate (100 micromoles) and a purified succinyl coenzyme A deacylase preparation (1·1 mgm. protein) from pig heart were added as indicated. The heart extract (5·6 mgm. protein) was made from pig heart acetone powder. Fraction 1 (11·3 mgm. protein) was an ammonium sulphate fraction (0·4–0·6 saturation) of the heart extract. Fraction 2 (9·2 mgm. protein) was obtained from fraction 1 by precipitation with ethanol (20–40 per cent) at − 15°. Fraction 3 (6·1 mgm. protein) was equivalent to fraction 2 but made from an extract of fresh heart. Volume, 2·0 ml.; incubation, 60 min. at 38° (25° for fraction 3)

Additions to assay system	Micromoles of acetoacetate formed			
	Heart extract	Fraction 1	Fraction 2	Fraction 3
None	0 (0)*	0·06	0·22	0
Succinate	0·39	0·77	0·90	0
Deacylase	0·05	0·14	0·12	
Succinate + deacylase	0·47 (0·27)	1·51	1·66	0·54

* Values in parentheses are for pig kidney extract

mercaptide bond of acetyl coenzyme A[8] (approximately 12,000 calories) and the calculated free energy of hydrolysis of acetoacetate[14] (16,000 calories). For the synthesis of acetoacetyl coenzyme A, $\Delta F \simeq 28{,}000\text{–}24{,}000 = +4{,}000$ calories. This corresponds to an equilibrium constant of about 10^{-3}. In heart, the equilibrium of reaction (6) can be shifted in favour of synthesis through coupling with reactions (5) and (8) when succinate is present. In liver, which does not catalyse reaction (5), this shift of equilibrium may be accomplished by the action of a specific acetoacetyl coenzyme A deacylase.

The occurrence of a reversible coenzyme A transfer from succinyl coenzyme A to acetoacetate (reaction 5) has important implications. If, as seems likely, acetoacetyl coenzyme A is generated by fatty acid oxidation, this process would result in phosphorylation at the substrate-level by reversal of reactions (5) and (4*a*).

We wish to thank Prof. Severo Ochoa for his interest in this work. We are indebted to Dr. S. Kaufman and Dr. C. Gilvarg for purified preparations of α-ketoglutaric dehydrogenase and succinyl coenzyme A deacylase from pig heart. The work was supported by grants from the United States Public Health Service, the American Cancer Society (recommended by the National Research Council Committee on Growth), the Williams–Waterman Fund of the Research Corporation, and by a contract between the Office of Naval Research and New York University College of Medicine.

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ELECTRON MICROSCOPY OF MITOCHONDRIA AND CYTOPLASMIC DOUBLE MEMBRANES

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Ultra-Structure of Rod-shaped Mitochondria

By means of an improved technique using a modified Spencer No. 820 rotary microtome[1] and specially polished razor blades[2], it has been possible to obtain tissue sections sufficiently thin to study the structure of tissue cells in sections at a resolution of better than 30 A.

A second factor of importance in this connexion is the improvement of the osmium fixation technique through the modifications recommended for electron microscopy by Pallade[3].

A third factor is represented by the demonstration by Hillier[4] of the deteriorating effect of removing the embedding medium by solvents exhibiting considerable surface forces when evaporating. To study the structure of the cells at a high resolution it is therefore necessary to avoid the removal of the embedding medium, although this means subjecting the sections to a high beam intensity.

The mitochondria have been studied at a resolution of about 30 A. in the retinal rods of the guinea pig eye, in the excretory cells of the mouse pancreas and (in collaboration with J. Rhodin) in the proximal convoluted tubules of the mouse kidney[5].

A similar structure has been revealed in all these cases, and the presumed identification of certain structural components as mitochondria in the retinal rods was based on the characteristic ultra-structure and was later confirmed by supravital staining with janus green *B*[6].

In all three kinds of cells the mitochondria are rod-shaped and lined by an outer double membrane. In the interior of the mitochondria there is a great number of transversally oriented inner double membranes with different spacings in the different types of cells studied. The outlines of these double membranes also differ in cells of different tissues, being rather irregular in the rod inner segment mitochondria. Fig. 1 illustrates the tubular cell mitochondria of the mouse kidney and Fig. 2 the rather similar appearance of the retinal rod mitochondria in the rod inner segment from the guinea pig.

The dimensions of the outer and the inner membranes are identical as measured in the electron micrographs. For the mitochondria of the proximal convoluted tubule cells, the mean total thickness is 160 A. This figure is the mean value of 1,200 measurements on twenty-five different mitochondria. The thickness of the two constituent single membranes is 45 A., and the space in between the single membranes measures 70 A.

The mitochondria of the retinal rods are located in the inner segment, where the long slender mitochondria are tightly packed, and the whole aggregation of mitochondria forms the so-called ellipsoid.

The double character of the membranes observed in the mitochondria does not depend upon a diffraction phenomenon, as the pictures represent close-to-focus pictures in through-focus series, and the two constituent single membranes exhibit

Fig. 1

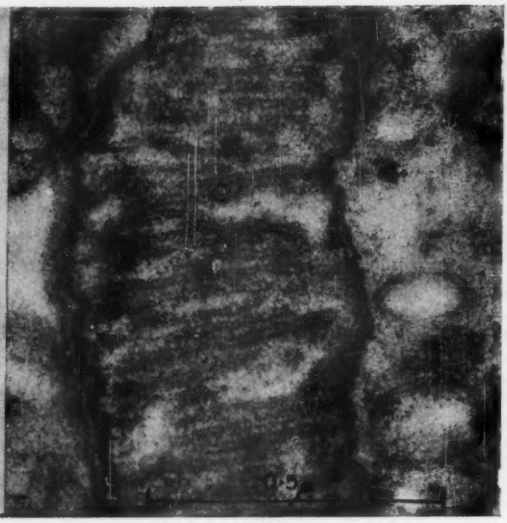

Fig. 2

Fig. 1. Part of a rod-shaped mitochondrion from the proximal convoluted tubule of mouse kidney; in the upper right corner a part of a cell nucleus with the double nuclear membrane and in the upper left corner a part of a cell granule. Along the lower side of the mitochondrion some intracellular cytoplasmic membranes are seen. Ultra-thin section. Magnification, × 97,000

Fig. 2. Part of a mitochondrion from the inner segment of retinal rod of a guinea pig eye. The transversally oriented double membranes are more irregularly arranged than in the tubular cells, due to the more irregular outlines when observed in a direction parallel to the long axis of the mitochondrion. Ultra-thin section. Magnification, × 90,000

sufficient deviations from a parallel course to demonstrate a certain mutual independence. On the other hand, the variations regarding the spacing are sufficiently small to justify considering the two membranes as parts of the same structural element.

Another possibility would be that the double appearance was due to a single membrane oriented obliquely to the direction of the electron beam and with an enhanced contrast along the cut margins of the membrane in the upper and the lower surfaces of the section. This is excluded by, among other conditions, the fact that the spacing is independent of the thickness of the sections.

Experience with osmium fixation shows that it is an excellent electron stain for protein membranes[7].

It has tentatively been assumed that the double membranes represent two membranes of mainly protein character separated by a double layer of lipid molecules. This assumption is supported by the dimensions measured, 45 A. representing a reasonable thickness for a protein membrane and 70 A. corresponding to the thickness of a double layer of, for example, mixed myelin sheath lipids[8]. [Aug. 11.

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Systems of Double Membranes in the Cytoplasm of Certain Tissue Cells

RECENT developments of the technique for making ultra-thin sections for electron microscopy[1] have made it possible to study the ultra-structure of tissue cells at high resolution (better than 30 A.) with the topography of the structural elements preserved.

A rather highly developed system of double membranes was first observed in the cytoplasm of the excretory cells of the mouse pancreas preserved by freeze-drying and embedded directly after drying in *n*-butyl-methacrylate (Fig. 3). Suspecting that the striking organization might be an artefact due to a stepwise advance of freezing through the cell, osmium-fixed material was analysed. The same systems of double membranes were observed in this material (Fig. 4). These circumstances constitute good evidence that the double membranes are real structures and do not represent fixation artefacts, the osmium fixation and the freeze-drying acting according to quite different principles.

The double membranes are oriented mainly parallel to the cell membrane, and up to about forty double membranes may be observed in the space between the cell membrane and the nucleus.

Such a structure might produce an anisotropy of the cytoplasm. A preliminary polarization optical analysis of the living pancreas cells in the living mouse has revealed an anisotropy of the cytoplasm, negative with respect to a direction perpendicular to the cell surface and with the optical axis parallel to this direction. This anisotropy might well correspond to a system of membranes oriented parallel to the cell surface. The polarization optical analysis is still incomplete.

The electron microscopic observations on freeze-dried and osmium-fixed material thus seem to be confirmed by the polarization optical analysis on living cells.

The mean total thickness of the double membranes is 530 A. when measured on frozen-dried material and 600 A. when measured on osmium-fixed material. The mean distance between the centres of the two constituent single membranes is 370 A. and 360 A.

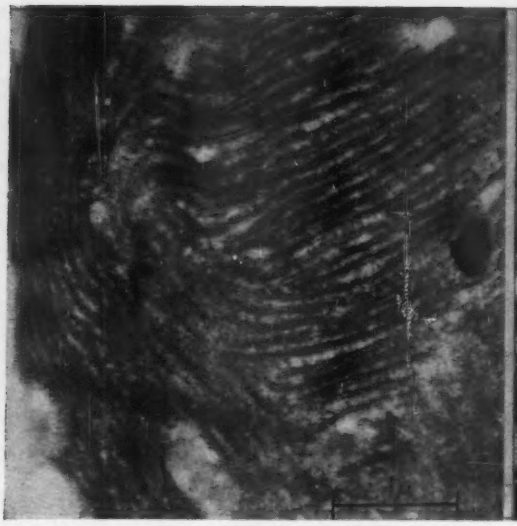

Fig. 3

Fig. 4

Fig. 3. Cytoplasm of mouse pancreas excretory cell; fixation by freeze-drying. A characteristic pattern of double membranes. Thin section. Magnification, × 18,000

Fig. 4. Cytoplasm and part of the nucleus of a mouse pancreas excretory cell; buffered osmium fixation. A system of double membranes similar to those in Fig. 3 is shown. In the upper part of the picture several double membranes with wide spaces separating the two constituent single membranes are seen. Thin section. Magnification, × 22,000

for frozen-dried and osmium-fixed material, respectively. The calculated mean thickness of the single membranes is 160 A. (frozen-dried) and 240 A. (osmium-fixed), and the width of the space between the two membranes of the double membrane is 210 A. (frozen-dried) and 120 A. (osmium-fixed). These figures are preliminary, as each is based on only sixty to eighty measurements.

The double membranes appear coarser after osmium fixation than after freeze-drying, presumably due to osmium-stained components with a close topographical relation to the membranes or to the precipitation of proteins at the membranes.

Intracellular double membranes have also been observed in the cells of the proximal convoluted tubules of mouse kidney[2], and in the epithelium of mouse intestines. In the kidney tubular cells the intracellular membranes occur in the basal cell zone and divide the cytoplasm into compartments containing the mitochondria. The total mean thickness of these double membranes is 270 A. (mean value of 600 measurements on twenty-five membranes), the thickness of the constituent single membranes 80 A., and the width of the space between the single membranes 110 A.

These figures show a distinct difference in dimensions between the intracellular cytoplasmic membranes of the pancreas and of the kidney cells. They also differ in regard to the effect caused by the osmium fixation. The double membranes of osmium-fixed pancreas cells often appear deformed, with the two constituent single membranes separated by more-or-less wide spaces. The double membranes may even appear as wide tubules. As the double membranes do not show this appearance in frozen-dried material, it seems reasonable to assume that the wide spaces are due to the osmium fixation causing a swelling of the double membranes.

The double membranes of the tubular cells of the kidney and of the epithelial cells of the intestines have not been observed to exhibit that deformed pattern. On the contrary, the distance between the constituent single membranes of these double membranes is fairly constant.

The double membranes of the pancreas cells thus differ considerably from the double membranes in the kidney and intestinal cells both in dimensions and variability of the spacing. It therefore seems justified to assume that we are dealing with rather different intracellular double-membrane structures.

The intracellular cytoplasmic membranes seem to correspond to the coarse cytoplasmic fibrils first observed by J. Hillier[3] in liver cells in connexion with his work on improving the sectioning technique and recently described by Bernhard, Gautier and Oberling[4] in liver, pancreas and salivary gland cells.

Double-membrane structures have also been observed as an important structural element of the mitochondria[5] and in the outer segments of the retinal rods of guinea pig and perch eyes[1].

The following interpretation of the observations is proposed. The two constituent single membranes represent membranes of mainly protein nature and the space between represents a multilayer of lipid molecules, partially dissolved during the embedding. This tentative interpretation seems justified, at least for the intracellular double membranes of kidney and intestinal cells. The structural organization of the double membranes of the pancreas cells, on the other hand, may well be more complex.

The intracellular cytoplasmic membranes may represent a fundamental principle of organization of the cytoplasm. [Aug. 22.

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LETTERS TO THE EDITORS

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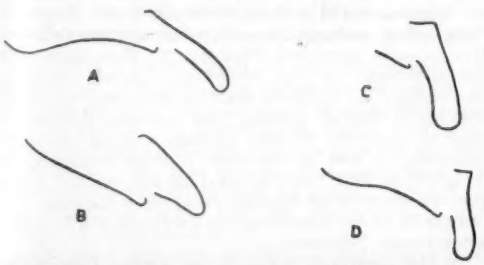
The Nature of *Telanthropus capensis*

THE type mandible of *Telanthropus capensis* was found in the Swartkrans excavation in April 1949 by me. Dr. R. Broom and I published a preliminary description in this journal[1]. In this note the opinion was expressed that this form is "intermediate between one of the ape-men and true man". This conclusion has been somewhat sceptically received by most workers, who consider, in view of the fact that the same excavation has yielded numerous remains of the ape-man *Paranthropus crassidens*, that the specimen is more likely to be a small and slightly aberrant *P. crassidens* than a new type of man.

Hitherto the known specimens of this form comprised only the almost complete mandible containing five molars, P_3 belonging to the left side of the same mandible and the proximal end of a radius. The teeth are small compared to the *P. crassidens* homologues—especially M_1. The length and breadth values for M_1, respectively, fall 5·4 and 3·8 standard deviations from the corresponding means for M_1 of *P. crassidens*. The ascending ramus and corpus mandibulæ heights are appreciably lower than those of *P. crassidens*. Although the molars show general agreement in structure with the latter form, there are some points of divergence, such as the extended buccal grooves and absence of buccal pits—the latter being a prominent and consistent feature of *P. crassidens*. On this and other evidence[2], it is considered that *Telanthropus* is certainly distinct from *P. crassidens*.

The exact nature of *Telanthropus* is perhaps less easily determined. However, a recently cleaned specimen from Swartkrans has proved to belong to this form and has thrown valuable new light on the matter. The specimen consists of a well-preserved portion of a snout with part of the palate intact. This differs from the corresponding region of *P. crassidens*, of which ten specimens of this region are known. The angle of slope of the subnasal region corresponds with that in euhominids, but not with that in any known prehominid, and the palate is deep anteriorly. The nasal spine is small. The subnasal plane of the maxilla does not pass smoothly and insensibly into the floor of the pyriform aperture, as is the case in all the known australopithecines, but does so in a pronouncedly euhominid fashion: there is a sharp change of plane at the lower margin of the pyriform aperture. The bony plate inside the nasal aperture is almost at right-angles to the subnasal plane. The left canine socket is intact except for the outer wall and is too small to accommodate even the smallest lower canine root of *P. crassidens*. The smallest upper canine root of the latter form is much too large for this socket. This probably means that in *Telanthropus* both the crown and root of the canines were reduced in size, whereas in *P. crassidens* the crown had been reduced but not the root. From the various fragments of P^3 preserved on both sides, it seems that this tooth was still three-rooted; which condition is also found in the australopithecines.



Sagittal sections through the snouts of (*A*) *Plesianthropus*, (*B*) *Paranthropus crassidens*, (*C*) *Telanthropus* and (*D*) Bushman. In *B* and *C* the posterior portion of the palate is missing. All oriented on the Frankfort plane and ½ natural size

This snout differs, therefore, in a number of important features from those of the australopithecines and approaches the condition in the earliest known euhominids very closely. In conjunction with the characters of the mandible, there seems little doubt that *Telanthropus* is a very primitive euhominid. There are some australopithecine affinities, and it is therefore difficult to avoid the conclusion that this form had recently passed from australopithecine to euhominid status.

Recent geological and faunal evidence[3] strongly suggests that the Swartkrans site is Upper Pliocene in age and that it is all a uniform deposit, that is, that the *Telanthropus* and *P. crassidens* remains are coeval. *Telanthropus* is therefore of very great interest and significance for studies on hominid phylogenesis. It demonstrates the very close relationship between australopithecines and man, and is almost certainly the oldest euhominid so far known. A fuller account is being published elsewhere.

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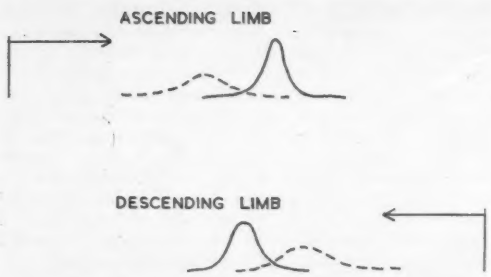
Nov. 25.

[1] Broom, R., and Robinson, J. T., *Nature*, **164**, 322 (1949).
[2] Broom, R., and Robinson, J. T., Transvaal Museum Mem. No. 6, 110 (Pretoria, 1952).
[3] Robinson, J. T., *Ann. Transvaal Museum* (in the press).

Separation of an Inhibitor of Influenza Virus Hæmagglutination from Human Sputum

A SIMILARITY exists between the action of the influenza virus enzyme on the surface of the erythrocyte or cells of the respiratory tract and its action in destroying the inhibitory properties for virus hæmagglutination possessed by certain soluble mucins. This has stimulated much interest in the biological function of the mucins in relation to influenza virus infection and particularly in their chemistry as substrates for influenza virus enzyme action[1]. Although studies since 1948 have dealt with influenza virus action on a variety of inhibitors, ranging from those obtainable from serum and urine to those from egg-white, sheep salivary gland and human ovarian cyst, relatively little attention has been paid to the inhibitors present in the secretions actually at the site of influenza virus infection, namely, those in the human nasal and bronchial mucus. Fazekas[2] has described the change in 'inhibitor profile' for certain influenza viruses which takes place in human nasal mucus during influenza. Rose[3] has reported that sputum contains factors which inhibit both infectivity (in eggs and mice) and hæmagglutination by influenza virus.



Electrophoresis of sputum inhibitor in potassium phosphate buffer (pH 7·0, $\mu = 0{\cdot}1$) at 3·2 volt/cm. for 14,400 sec. Concentration approximately 0·4 per cent. Before (———) and after (– – – – –) treatment with receptor-destroying enzyme

Preliminary experiments carried out by us to extend the observations of Rose have shown that the factor present in some sputa which inhibits the growth of influenza virus *in ovo* seems to be distinct from the factor constantly present in all sputa which inhibits hæmagglutination *in vitro* by both enzymically active and 'indicator' viruses. It has been possible to extract from sputum an inhibitor of hæmagglutination which appears to be a single substance. The purification and properties of this inhibitor are described in this communication.

Samples of sputum, from patients with chronic bronchitis, were homogenized for five minutes in a Waring blendor in ten times their volume of physiological saline. The solution was centrifuged (5,000 *g*, 20 min.) to remove bacteria and cell debris. The supernatant was centrifuged (20,000 *g*, 25 min.) to remove an aggregated mucinous component. The inhibitor was precipitated from this supernatant by the addition of an equal volume of acetate buffer (pH 3·6, ionic strength (μ) = 1·0, containing 0·02 *N* calcium chloride). The presence of calcium ions was found necessary for satisfactory precipitation. The precipitate was recovered by centrifugation (3,000 *g*, 10 min.) and dissolved in a minimum volume of phosphate buffer (pH 7·0, $\mu = 1{\cdot}0$). The resulting slight precipitate of calcium phosphate was removed by centrifugation (2,000 *g*, 15 min.). The supernatant was submitted to electrophoresis in phosphate buffer (pH 7·0, $\mu = 0{\cdot}1$). A single component migrating towards the anode with a mobility of $6{\cdot}7 \times 10^{-5}$ cm.^{2} sec.$^{-1}$ volt^{-1} was found (see diagram). After treatment with a purified preparation[4] of the receptor-destroying enzyme of *Vibrio choleræ* the mobility of this component was reduced to $4{\cdot}9 \times 10^{-5}$ cm.^{2} sec.$^{-1}$ volt^{-1}. This reduction in mobility after the action of the receptor-destroying enzyme has been found to be general for inhibitors and gives an indication of the uniformity of the substance as an inhibitor[5].

The inhibitory titres of the samples submitted to electrophoresis were estimated according to the method of Stone[6], using the viruses shown in the table.

	Active viruses			Indicator viruses		
	Mel	Lee	WSE	Mel	Lee	WSE
Untreated sputum inhibitor	200	80	1,000	9,000	4,000	8,000
Sputum inhibitor treated with receptor-destroying enzyme	10	10	10	10	10	10

Details of this work will be published elsewhere.

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[1] Burnet, F. M., *Physiol. Rev.*, **31**, 131 (1951).
[2] Fazekas de St. Groth, S., *Nature*, **167**, 43 (1951).
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[4] Ada, G. L., and French, E. L., *Aust. J. Sci.*, **13**, 82 (1950).
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[6] Stone, J., *Aust. J. Exp. Biol. and Med. Sci.*, **27**, 337 (1949).

Aureomycin in *Theileria parva* Infection

Recognition of the selective action of quinine, atebrin and chloroquine on the hæmotropic trophozoites of certain *Plasmodium* species, and that of plasmoquine on the exoerythrocytic trophozoites as well as on the gametocytes, forms the bases of modern chemotherapy of malaria in laboratory animals and in man.

Application of this conception of selective chemotherapeutic action to other diseases caused by protozoa, the life-cycle of which is similar to that of the malarial parasite, notably the *Theileria* spp., appeared to be indicated. Neitz[1] reported that the 8-aminoquinoline preparation plasmoquine has a selective action on the hæmotropic forms of *Theileria parva*, while leaving the schizont phase unaffected. Therefore the drug had no curative value. The investigation was extended to include other drugs, among which was aureomycin. The antibiotic, administered intravenously in repeated large doses during the incubation period of infection, has been found to exert a marked effect upon the schizonts of *Theileria parva*. In fact, in each of seven cases of sporozoite-induced theileriasis, disappearance of schizonts was followed by recovery and the development of a solid immunity.

For these tests, nine cattle were used, of which two served as untreated controls. In each case the disease was induced by feeding infective *Rhipicephalus appendiculatus* nymphæ on the left ear. Treatment was commenced 24 hr. later by the injection of aureomycin in a dose of 10 mgm. per kgm. body-weight. The same dose was repeated at arbitrary irregular intervals as indicated in the accompanying table, until a decrease in the number of schizonts in lymph gland smears became evident. In each case from this stage the number of schizonts continued to decrease rapidly until they could no longer be found after prolonged search. Hæmotropic forms of the parasite persisted from one to five days after disappearance of the schizonts. Apart from an exceedingly mild febrile reaction and swelling of the superficial lymph glands, the animals showed no clinical evidence of the disease. After complete recovery, it was shown that a solid immunity to re-infection had been induced in one animal tested four weeks after disappearance of the schizonts. The immunity of the remaining six survivors will be tested after longer intervals.

In the untreated controls the normal fulminating form of the disease was produced, followed by death not later than the twenty-fourth day after attachment of the ticks.

Days	Treated animals							Untreated animals	
	5085	5430	5438	5483	5614	5436	5444	5700	5704
1	*X*	*X*	*X*	*X*	*X*	*X*	*X*		
2				*X*	*X*	*X*	*X*		
3	*X*	*X*	*X*	*X*	*X*	*X*	*X*		
4		*X*	*X*						
5	*X*			*X*	*X*				
6		*X*	*X*			*X*	*X*		
7	*X*			*X*	*X*				
8		*X*	*X*						
9				*X*	*X S+*	*X S+*	*X S+*		
10	*X*	*X*	*X*	*S+*	*S+*	*S+*	*S+*		*S+*
11		*S+*		*X S+*	*X S+*	*X S2+*	*X S2+*	*S+*	*S2+*
12	*X S+*	*X S+*	*X*	*S+*	*S3+*	*S2+*	*S2+*	*S+*	*S3+*
13	*S+*	*S+*	*S+*	*X S2+*	*X S3+*	*X S3+*	*X S3+*	*S2+*	*S3+*
14	*X S2+*	*X S+*	*X S+*	*S2+*	*S2+*	*S3+ P+*	*S4+ P+*	*S2+*	*S4+ P+*
15	*S2+*	*S+*	*S2+*	*S+*	*S2+*	*X S3+ P2+*	*X S4+ P2+*	*S3+ P+*	*S4+ P+*
16	*S2+*	*X S+*	*X S2+*	*S+*	*S2+*	*X S4+ P3+*	*X S4+ P2+*	*S3+ P+*	*S4+ P+*
17	*X S2+*	*S+*	*S+*	*S+ P+*	*S+ P+*	*S4+ P3+*	*S3+ P3+*	*S4+ P2+*	*S4+ P4+*
18	*S3+*	*X*	*X S+*	*P+*	*P+*	*X S4+ P3+*	*X S3+ P3+*	*S4+ P3+*	*S5+ P4+*
19	*S2+*	*P+*			*P+*	*X S4+ P3+*	*S3+ P4+*	*S5+ P4+*	*S5+ P4+*
20	*S2+ P+*	*P+*	*P+*		*P+*	*X S4+ P4+*	*S2+ P4+*	*S5+ P5+*	*S5+ P5+*
21	*P+*		*P+*		*P+*	*S3+ P4+*	*S+ P4+*	*S5+ P5+*	*S5+ P5+*
22	*P+*		*P+*			*S3+ P3+*	*S+ P3+*	*S5+ P5+*	*S5+ P5+*
23	*P+*		*P+*			*S2+ P3+*	*P3+*	*S5+ P5+*	*S5+ P5+*
24						*S+ P3+*	*P2+*	*S5+ P5+*	*S5+ P5+*
25						*P+*	*P+*		

X, treatment with aureomycin; *S2+*, schizonts 2+ present in smears; *P+*, hæmotropic parasites present; + very rare; 2+, rare; 3+, fairly frequent; 4+, frequent; 5+, numerous

Thus aureomycin in a dose of 10 mgm. kgm. body-weight administered in repeated doses during the incubation period of *Theileria parva* infection is a schizonticide which acts on the early schizonts by suppressing nuclear division. This in turn suppresses the formation of merozoites, which invade either the lymphocytes or erythrocytes. The drug appears to have no effect upon the hæmotropic parasites. The result is that completion of the cyclical development of sporozoite-induced infection is inhibited and the clinical disease fails to develop. Nevertheless, a solid immunity is produced.

There remains to be determined the minimum effective dosage and the effect possibly in combination with a drug affecting the hæmotropic parasites, for example, plasmoquine administered at a later stage of parasite development.

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A New Technique for Microscopic Preparations of Small Marine Animals

During a recent study of the platyctenid ctenophores of Jamaica, the following technique was devised to allow even the most delicate and minute platyctenid to be immobilized, fixed, stained and embedded in any desired position with the minimum distortion. As this method has since been used successfully with rhabdocœl turbellaria, it is felt that its usefulness might well be extended to a wider range of invertebrates.

The chief difficulty in obtaining flat, uncontracted specimens of these delicate animals is their marked intolerance of usual anæsthetics such as menthol, magnesium sulphate, urethane or chloral hydrate. Treatment with warm fixative is also very often unsuccessful, as the animals begin to contract as soon as the fumes of the fixative reach them before the liquid can be applied. The usual refrigerator 'freezing and thawing in fixative' method is also of no use as the animals either dissolve while in the ice cube, or become only partially fixed, or become fixed in an unnatural position. These difficulties have been overcome by the following method.

(*a*) *Immobilization and Fixation.* The platyctenid is allowed to take up either its normal 'sitting' position in a drop of sea water on a coverslip (preferably No. 1 thickness) or is allowed to flatten itself under the surface film of the drop. The coverslip is then gently transferred to the stage of a freezing microtome. The animal is given a moment or two to recover from any jarring, and then the supply of carbon dioxide from the cylinder is turned on. The sea water drop is carefully watched until it just becomes opaque, then the carbon dioxide is turned off. The drop continues to freeze for a few moments, and it is during this interval that the fixative is added drop by drop. After the fourth or fifth drop of fixative the sea water begins to thaw, but the animal remains motionless and the requisite amount of fixative may be poured on. Fixatives which can be recommended are, in order of preference, (1) Komai's[1] modification of Carnoy–Lebrun, consisting of 70 parts saturated aqueous sublimate solution, 30 parts 95 per cent alcohol, and 1·5 parts glacial acetic acid; and (2) Duboscq–Brasil.

(*b*) *Staining for Whole Mounts.* The animal remains attached to the coverslip after freezing with carbon dioxide, and staining may therefore be carried out by the gentle removal of the coverslip with the animal from one Petri dish to another. The final mount is obtained by inverting a slide over the animal in a drop of mountant on the original coverslip. The staining process should be as rapid as possible because of the fragile nature of the specimen. A progressive stain such as aceto-carmine usually gives

good results and makes the addition of a differentiator to the list of staining solutions unnecessary.

(*c*) *Embedding.* The animals may be prepared for embedding in paraffin, ester wax[2] or in celloidin by a very simple modification of the above technique. A small square of thin 'Cellophane' is placed on the coverslip and held in position by a drop of sea water. A further drop is then placed on the upper surface of the 'Cellophane' and the animal transferred from the aquarium to this drop. Upon freezing as in section (*a*), the animal will now adhere to the 'Cellophane' instead of to the coverslip. After fixation and thawing, the coverslip with the 'Cellophane' and animal is transferred to 70 per cent alcohol and is then taken through the usual solutions for either wax or celloidin embedding.

For ease of handling of the coverslip, especially in celloidin solutions, a cradle made of fine copper wire and suspended from the cork by thread will be found to be helpful. In the actual embedding process, the coverslip, which merely acts as a stiffening support, is removed, but the 'Cellophane' is embedded along with the animal and may then be stripped off just prior to cutting.

Clearly this method of fixation owes much of its success to controlling the degree of freezing, which necessitates keeping the animal under observation from start to finish of the process. This can easily be tested in two simple experiments. First, if platyctenids are frozen into a hard block of ice and then allowed to thaw (without fixation), they will disintegrate, chiefly because the character of the mesoglœa appears to be altered, so that it is no longer capable of holding the animal together. This may perhaps be related to the high water content of the animal. Secondly, if the animals are frozen only slightly, as suggested in section (*a*) (without fixation), they will recover completely, and their normal movements may again be studied under the microscope.

The possibility that the carbon dioxide may have a gentle anæsthetizing effect cannot be entirely ruled out; but further experimentation would be required to elucidate this point.

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[1] Komai, T., *Mem. Coll. Sci., Kyoto*, B, **17**, (1), 1 (1942).
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X-Ray Evidence for Metal-to-Metal Bonds in Cupric and Chromous Acetate

As a preliminary to the structural determination of chromous acetate, it was decided to study the much more stable cupric acetate $Cu(CH_3COO)_2.H_2O$ during the early X-ray investigations. Both these compounds are monoclinic with space group $C2/c$, and their unit-cell dimensions, determined from X-ray measurements and given herewith, are almost identical.

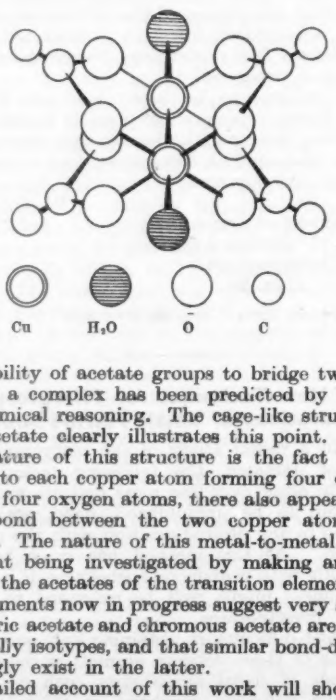
	a	*b*	*c*	*β*
Cupric acetate	13·15	8·52	13·90 A.	117° 0′
Chromous acetate	13·15	8·55	13·94 A.	117° 0′

The values for cupric acetate are in good agreement with those found by Hull and given in the "Handbook of Chemistry and Physics" (13th edit., p. 2066).

The close resemblance between these two acetates suggests that they are structurally isotypes, so that it appeared likely that an X-ray examination of cupric acetate might give information as regards the structure of the unstable chromous acetate.

Assuming eight $Cu(CH_3COO)_2.H_2O$ formula units in a cell with the above dimensions, the calculated density is 1·92 gm.cm.$^{-3}$, which is the same as the value determined experimentally by the method of flotation. Patterson projections, Harker sections and Fourier projections of the structure on three crystallographic planes show that the true repeat unit is $Cu_2(CH_3COO)_4.2H_2O$. It was further found that the symmetry centre of this dimeric molecule coincides with a symmetry centre of the $C2/c$ space group. The unit cell therefore contains only four molecules.

The accompanying diagram is of the cupric acetate molecule, obtained by calculating bond-lengths and angles from the projections. The nearest six neighbours of a copper atom are comprised of four oxygen atoms belonging to four different acetate groups, a copper atom and a water molecule. These six atoms form a distorted octahedral configuration about each of the two copper atoms in the molecule. The Cu–O distances all approach the value 1·97 A., which is in good agreement with the normal Cu–O [1] and Cr–O [2] distances found in other compounds. The four acetate groups are separately planar and their dimensions conform to previously determined bond-lengths and angles. The Cu–H_2O distance is 2·20 A. The Cu–Cu distance is 2·64 A., and is only slightly longer than the value 2·56 A. found in metallic copper.



The ability of acetate groups to bridge two metal atoms in a complex has been predicted by Werner[3] from chemical reasoning. The cage-like structure of cupric acetate clearly illustrates this point. An unusual feature of this structure is the fact that, in addition to each copper atom forming four covalent bonds to four oxygen atoms, there also appears to be a fifth bond between the two copper atoms in a molecule. The nature of this metal-to-metal bond is at present being investigated by making an X-ray study of the acetates of the transition elements.

Experiments now in progress suggest very strongly that cupric acetate and chromous acetate are, in fact, structurally isotypes, and that similar bond-distances accordingly exist in the latter.

A detailed account of this work will shortly be published elsewhere. This communication is pub-

lished by permission of the South African Council for Scientific and Industrial Research.

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[1] Tunell, G., Posnjak, E., and Ksanda, C. J., *Z. Krist.*, A, **90**, 120 (1935).
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Surface Free-Energy of Solid Paraffin Wax

As part of a programme of research on the surface free-energy of solids, we have lately been working on paraffin wax. The method used is the one proposed by Bergren[1] and consists in measuring the rates of elongation or contraction of thin filaments of different lengths hanging under their own weights. The change in length results from two opposing forces: one which tends to shorten the filament so that its surface free-energy is decreased, and the other tending to lengthen the filament because of its weight. A critical filament-length, l_0, is determined at which the elongation of the upper part of the filament is equal to the contraction of the lower part, so that the length remains constant. Assuming that the solid near the melting point behaves as a viscous liquid, that is, the rate of deformation is proportional to the applied stress, the surface free-energy of the solid can be calculated from the critical length l_0 using the equation:

$$\gamma = \tfrac{1}{12}\rho g r l_0^2$$

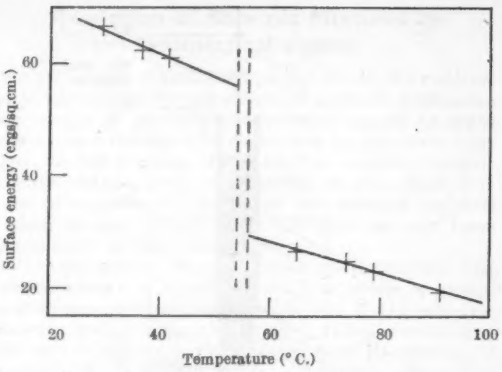
where γ is surface free-energy, ρ is density of solid at temperature of experiment, g is acceleration due to gravity, and r is radius of wire.

In our experiments, filaments of 0·01088 cm. radius were produced by extrusion of the paraffin wax (melting range 54–56° C.) through a tungsten carbide die at room temperature into a constant temperature (± 0·1° C.) enclosure. The observations were then made on the filament hanging from the die. The change in length was measured at intervals by means of a cathetometer, and $\Delta l/l\Delta t$ (positive or negative) plotted against the original length of the filament. This should be a straight line according to theory, and l_0 was obtained by interpolation as intercept on the length axis.

Measurements were carried out at 29·5°, 36·7° and 41·5° C., and the surface free-energy calculated using $\rho_{20°C.} = 0{\cdot}8857$ gm./cm.³, the change in density being negligible over the temperature-range concerned. The results are plotted in the accompanying graph, together with values for the same specimen of paraffin wax in the liquid state determined by the ring tensiometer method and corrected by the method of Harkins and Jordan[2].

The results indicate a discontinuity in the surface free-energy on melting. On the other hand, the temperature coefficient of the surface free-energy does not alter appreciably.

The same method has been used for measuring the surface free-energy of tin (99·99 per cent pure) *in vacuo* at 215° C. (17° below melting point). Polycrystalline wires with transverse grain boundaries



Surface free-energy of solid and liquid paraffin wax

(1/25 cm. average longitudinal grain-size) were extruded from the electrically heated die directly into the evacuated constant-temperature chamber. After correcting for the grain boundary energy according to Udin[3], the surface free-energy at 215° C. was found to be 685 ergs/cm.².

Further work on the surface free-energy of tin and other low-melting metals at different temperatures is in progress. A detailed account of this will be published later.

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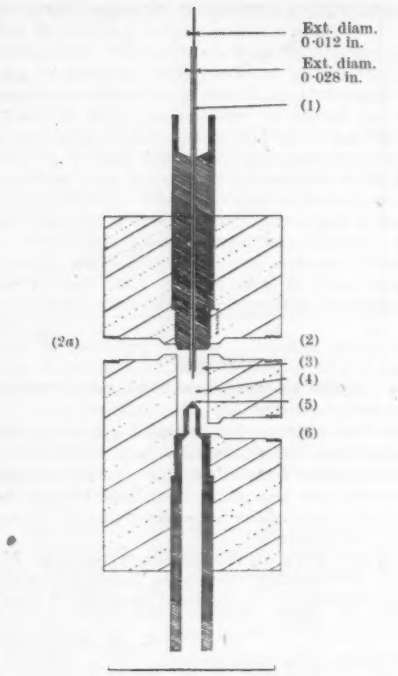
A Device for Counting Small Particles suspended in a Fluid through a Tube

ATTEMPTS to count small particles suspended in fluid flowing through a tube have not hitherto been very successful. With particles such as red blood cells the experimenter must choose between a wide tube which allows particles to pass two or more abreast across a particular section, or a narrow tube which makes microscopical observation of the contents of the tube difficult due to the different refractive indices of the tube and the suspending fluid. In addition, narrow tubes tend to block easily.

These difficulties can be overcome by slowly injecting a suspension of the particles into a faster stream of fluid flowing in the same direction. Provided there is no turbulence, the wide column of particles will then be accelerated to form a narrow column surrounded by fluid of the same refractive index, which in turn is enclosed in a tube which will not interfere with observation of its axial contents.

This principle has been applied to the alignment of red blood cells preparatory to electronic counting. The constructional details of the apparatus in use are shown in the diagram.



(1) Needle in holder; (2) and (2*a*) inflow tubes; (3) wide-bore tube; (4) observation area for (3); (5) vortex; (6) flushing tube

The whole apparatus is filled with gas-free distilled water which is allowed to flow via tubes 2 and 2*a* into the wide tube 4 and into the vortex 5. Tube 6 is normally closed. The suspension of cells is then passed into the needle (1). As the stream of cells emerges from the tapered tip of the needle it is narrowed by the faster peripheral stream in 3, and as the vortex is approached the stream of cells narrows further as the velocity increases.

To be robust and serviceable, the chamber is made of a solid brass block, drilled and tapped so that all the five tubes can be removed for cleaning or replacement. Three side tubes are used. By using tubes 2 and 2*a* for water to enter the chamber, the stream of cells passing from the needle to the vortex loses its tendency to curve which occurs if water enters from one side only.

Tube 6 is connected to a source of negative pressure. It is normally closed; but it is useful for flushing air or foreign material from the chamber.

Tube 3, which is circular in cross-section, approaches a square cross-section at the observation area (4). Here the walls are cut away and replaced with flat glass cover-slips sealed to the brass with wax compound. Ideally, tube 3 should be tapered and, from the point of view of accelerating the cells, rather narrower than it is. The needle and vortex are aligned as accurately as possible to be central to the wide bore.

The needle should be wide enough not to block easily but, provided it does not block, should be as narrow as possible to enable the velocity of cells passing through the needle to be substantially greater than the sedimentation effect of gravity. A further reason for a narrow needle is that if a constant flow-rate is used as a measure of the volume of cell suspension to be counted, the fluctuations of flow in a wide-bore needle will be greater for the same minute changes of pressure. A bore of about 125 μ has been found suitable. The needle is made of stainless steel.

The vortex tube has a small hole of 0·16 mm. diameter at its tip, the walls of which are tapered to 45° to reduce their optical interference when observing cells entering the tube. This tip is made of platinum to avoid corrosion. A negative pressure of 25 cm. of mercury is applied to the vortex. Poiseuille's formula and its derivatives and corrections cannot usefully be applied to flow in the chamber because the flow approaching the vortex has a radial component and also on account of cells interrupting the smooth gradient of pressure from the periphery to the centre.

The chamber at present in use functions moderately well. Dark-ground illumination is used, and a thin luminous stream of cells less than 10 μ wide, wavering slightly (not more than 5 μ to either side), is seen approaching the vortex but cannot be seen as it enters. The speed has been estimated as being between 3 and 6 cm./sec. as judged by oscilloscope measurements of the cells crossing a field of about 5 μ. It is hoped that this speed will be increased by redesigning the chamber with decreased diameter of the observation area, which at present is 3/16 in.

I am indebted to Dr. J. Cox for the construction of the apparatus, and to Messrs. Accles and Pollock, Ltd., who supplied the steel tubes.

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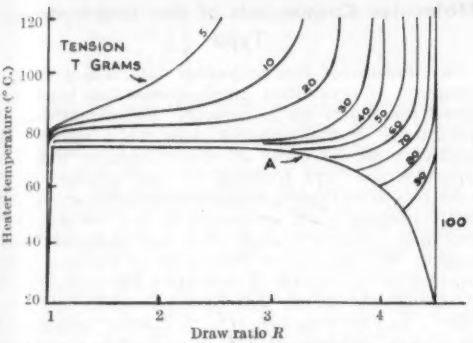
Drawing Synthetic Fibres

There are two aspects of the drawing of synthetic fibres which have not so far been treated very fully in the literature. These are, respectively, the behaviour of the fibre during continuous drawing on the machine (as opposed to simple stretching on a tensometer) and the formation and maintenance of a 'neck' during drawing[1]. These two problems are intimately related to one another, since a continuous drawing machine, operating as a steady-state tensometer, is a particularly suitable tool for examining 'necking'.

The starting point was to consider continuous machine drawing in terms of a three-dimensional load–extension–temperature surface characteristic of the material, which during most of our investigation has been polyethylene terephthalate ('Terylene'). A 'contour map' for such a surface for this material is shown in the accompanying graph.

It has been found that during continuous drawing between two rolls, with a heater mounted between, the extensions occurring in the yarn at all points in the thread-line can be explained in terms of this surface, whenever the yarn tension is less than that required to form a 'neck' in the cold fibre. Most of this region lies above the second-order transition tem-



Denier, 280; heater, 4 in. hot plate; speed, 7·5 cm./sec.

perature of the polymer, and drawing is then always uniform at all machine ratios.

Outside this region, where the tensions mount very rapidly, the material 'necks' at a ratio independent of the machine setting, but dependent on the diameter and initial molecular orientation of the specimen and upon the absolute speed of the machine. This is the normally observed 'cold-drawing' of the fibre. Under these conditions, the neck advances or retreats along the thread-line at a steady velocity which can be measured and used to calculate the natural draw ratio in the neck. In the graph the natural draw ratio thus calculated, for fibres of polyethylene terephthalate, is shown by the line *A*.

The natural draw ratio drops to unity at about 80° C. in the range of the second-order transition of the polymer[2].

Consideration of the phenomenon in the terms of the surface suggests strongly to us that it is due to self-heating of the specimen to a point where the effective load-extension curve becomes horizontal; that is, to where the extension occurs at constant load but rising temperature, rather than constant temperature and rising load. Conditions for this to happen can readily be calculated for model substances having simple load-extension temperature properties, when the essential criteria for 'necking' to occur appear to be: (1) a modulus which falls with increasing temperature; (2) a sufficient rise in temperature of the material caused by the work of stretching. This in turn implies: (*a*) poor conductivity; (*b*) that the work done appears as heat rather than elastic potential energy; (*c*) that heat losses must be small. Crystallinity in the material does not appear to be essential.

Parallel observations on such substances as nylons, polyethylene, gutta percha and polymethylmethacrylate, which is amorphous, appear to support these conclusions.

We hope to publish this work elsewhere at greater length.

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[1] Bunn and Alcock, *Trans. Farad Soc.*, **41**, 317 (1945). Wenderoth, H., *Koll. Z.*, **124**, 116 (1951). Horsley and Nancarrow, *Brit. J. App. Phys.*, **2**, 12 (1951).
[2] Kolb and Izard, *J. App. Phys.*, **20**, 564, 571 (1949).

Resolution of Racemic Mixtures by Symmetrical Agents

The recent communication by H. M. Powell[1] on new procedures for resolution of racemic substances by means of perfectly symmetrical agents prompts me to describe my own researches on the same subject. A full account of our results, including experimental details, is to be published in the *Anais Soc. Biol. Pernambuco*[2]. Although the method outlined below is very simple, apparently it has not been mentioned in the literature[3].

The proposed method is based upon the following assumptions: it is well known that optically active adsorbents preferentially adsorb one of the enantiomorphs from a racemic mixture[4,5]. When a crystalline racemic substance is precipitated from its solution, a crystallization nucleus is first developed. Since this nucleus contains a relatively small number of molecules there is more than an even chance that it will contain an excess of one enantiomorph or the other. Supposing that the forces acting in the growth of a crystal are of the same kind as those responsible for adsorption, this nucleus will grow preferentially, collecting one of the optical antipodes at the expense of the other, which will remain in the solution. Usually in a macro-crystal of dissymmetrical molecules obtained under perfectly symmetrical conditions the antipodal forms are so nearly equivalent in number that it is impossible by experimental means to prove the existence of an excess of one of the enantiomorphs, but this numerical equality only represents a statistical mean. It is possible, however, to increase the statistical fluctuations so that resolution can be shown.

In our experiments a racemic alkaloid, prepared synthetically (such as DL-narcotine or DL-laudonosine), insoluble in water, is first dissolved in hydrochloric acid, and a symmetrical organic base (pyridine) is then slowly poured into the solution, causing the re-precipitation of the alkaloid:

$$\text{pyridine} + [B\text{H}]^+\text{Cl}^- \rightarrow [\text{pyridine.H}]^+\text{Cl}^- + B.$$

After a small precipitate has formed, it is filtered off and the solution tested for optical activity. In our experiments with DL-narcotine and DL-laudonosine, resolutions ranging from 1 up to 2·5 per cent were achieved. The method can be applied to many other substances, and experiments are in progress on the resolution of DL-cystine and DL-tyrosine.

Finally, we wish to stress the implications of these findings (as well as those of Powell) on the problem of the origin of molecular dissymmetry in living matter. Processes such as those recently described are probably more likely to have occurred in the past than the activation of reactive racemic mixtures by naturally polarized light, even if they lead to a spontaneous decrease in the entropy of the system.

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[1] Powell, H. M., *Nature*, **170**, 155 (1952).
[2] Paper presented on July 10, 1952.
[3] See, for example, the exhaustive review by Ritchie, P. D., "Advances in Enzymol.", **7**, 65 (1947).
[4] Henderson, G. M., and Rule, H. G., *Nature*, **141**, 917 (1938).
[5] Karagunis, G., and Coumoulos, G., *Nature*, **142**, 162 (1938).

Emission of Molecular Complexes of Nitro-compounds

Lewis and Kasha[1] have directed attention to the phosphorescence induced by ultra-violet light on a number of organic compounds, particularly nitro-compounds, dissolved in the 'glass' produced when their solutions in suitable solvent mixtures are cooled to liquid-air temperature. They attribute this phenomenon to the formation of triplet-levels from the original excited singlets, the phosphorescence resulting from the triplet – ground-level change being unquenched owing to the greatly diminished thermal agitation at low temperatures in the glass.

We have found that even at ordinary temperatures an intense brick-red fluorescence is produced in ultra-violet light when an acetone solution of *s*-trinitrobenzene is shaken with a few crystals of potassium cyanide. In a mixture of methyl and ethyl alcohols (1 : 5), the fluorescence is orange-red; when this is frozen to a glass in liquid air, it exhibits a short-lived orange phosphorescence (with very dilute solutions the phosphorescence is green). We have examined other systems, not all of which show fluorescence at ordinary temperatures, but all of which emit radiations at liquid-air temperature. Our preliminary observations are recorded in the accompanying table.

In solution in methanol/ethanol (1 : 5)	Fluorescent colour at room temperature	Phosphorescent colour at liquid-air temperature
Sodium nitrite/sym-trinitrobenzene	—	blue
" " /chloranil	—	blue
" cyanide/*o*-dinitrobenzene	green	blue-green
" " /*m*- "	green	pale-blue
" " /*p*- "	greenish-brown	green
" " /sym-trinitrotoluene	—	red (green on dilution)
" " /chloranil	green	blue
" acetate/sym-trinitrobenzene	orange-red	yellow-green
Methylamine/sym-trinitrobenzene	red	orange

We believe that in these systems there is immediate complex formation, involving some donor–acceptor mechanism whereby a transition between molecular levels, originally forbidden, becomes permitted in the complex. Whether this level, distorted by the proximity of the donor molecule, corresponds to a level in the acceptor molecule or its ion, we cannot at present say.

We are grateful to Dr. E. J. Bowen for his suggestions and discussion.

Note added in proof. It may be mentioned that, since this letter was submitted, Reid[2] has described the emission spectra of certain hydrocarbon – aromatic nitrocompound complexes. He arrives at similar conclusions concerning the nature of the transitions involved.

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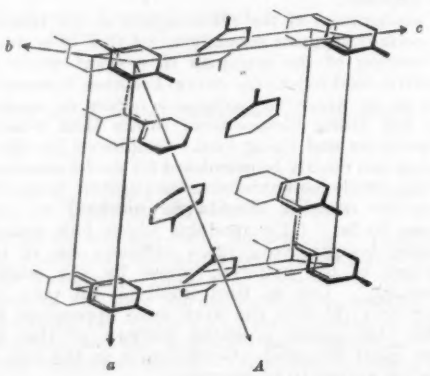
[1] Lewis and Kasha, *J. Amer. Chem. Soc.*, **66**, 2100 (1944).
[2] Reid, *J. Chem. Phys.*, **20**, 1212, 1214 (1952).

Molecular Compounds of the Quinhydrone Type

The nature of the molecular interaction in the formation of crystalline quinhydrones has been discussed previously by Anderson[1]. By comparison of preliminary crystallographic data for a number of quinhydrones, he came to the conclusion that the molecules are held together by the interaction of polar groups and polarizable aromatic substances, and that hydrogen-bond formation is not an essential structural feature, though it is not necessarily excluded. We have now been able to confirm these conclusions by a detailed structure determination of phenoquinone (which will be reported in full elsewhere), and by comparison with further preliminary data for quinhydrone and other molecular compounds of this type.

The arrangement of molecules in the unit cell of phenoquinone is shown in the accompanying diagram. Each quinone molecule, such as that at 000, is sandwiched between a pair of centrosymmetrically related phenol molecules, for example, those at $\frac{1}{2}\ 0\ \frac{1}{2}$ and $\frac{1}{2}\ 0\ \frac{5}{2}$. This results in the structure being built up of sets of three molecules arranged in columns parallel to the direction marked *A* in the diagram. In each set the plane of the quinone molecule is parallel to those of its two adjacent phenol molecules and is separated from them by a distance of 3·33 A. Each phenolic hydroxyl group forms a hydrogen-bond of length 2·64 A. with a quinone molecule in an adjacent column, two such hydrogen-bonds being indicated in the diagram by broken lines.



In order to compare this structure with that of quinhydrone, we must take into consideration the fact that, in the latter structure, the molecules must lie in special positions, since there are only two of each type of molecule in a cell of space-group $P2_1/c$. Further, on X-ray photographs taken with the crystal oscillating about its *a*-axis, the extremely low intensity of reflexions on layer lines of odd order indicates an almost exact repetition of the structure at intervals of $a/2$ parallel to the *a*-axis. The only choice of special positions which makes this arrangement possible necessitates the stacking of quinone and quinol molecules alternately, in continuous columns along the *a*-axis. This means that the unit cell of quinhydrone must be compared with the cell formed by the *A*-, *b*- and *c*-axes of phenoquinone as shown below.

Quinhydrone	Phenoquinone
$a_0 = 7{\cdot}55$ A.	$A_0 = 11{\cdot}62$ A.
$b_0 = 6{\cdot}05$ A.	$b_0 = 5{\cdot}97$ A.
$c_0 = 11{\cdot}55$ A.	$c_0 = 11{\cdot}48$ A.
$\beta = 110°$	$\beta = 109°$

It may be seen that there is a close similarity between the two sets of cell dimensions, except that the a-dimension of quinhydrone is approximately equal to two-thirds of the A-dimension of phenoquinone. This factor of two-thirds relating the two dimensions is to be expected in view of the change in stoichiometric composition from 1 quinone/2 phenol to 1 quinone/1 quinol. When this is taken into consideration, it follows that the arrangement and orientation of the molecules must be very similar in the two structures. It therefore appears that the essential structural feature in this type of molecular compound is the plane-to-plane stacking of alternate polarizing and polarizable molecules. Where hydrogen-bonding is possible, as in these two complexes, it must also be of importance in determining the structural arrangement, since it is to realize the full hydrogen-bonding potentialities of the molecules that the change in stoichiometric composition occurs.

In order to investigate the extent to which the principle of plane-to-plane stacking of alternate component molecules determines the structure of molecular compounds, an X-ray crystallographic survey is being made of such series of complexes as those formed by quinones and by aromatic nitro compounds. For all those so far investigated (complexes between hexamethyl-benzene and chloranil, trinitrobenzene and anthracene, trinitrobenzene and naphthalene), it has been possible to propose trial structures based on this principle. The only detailed structure determination which has so far been carried out for a molecular compound formed by trinitrobenzene, namely, with *p*-iodoaniline[2], also shows this same type of molecular arrangement.

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[1] Anderson, J. S., *Nature*, **140**, 583 (1937).
[2] Powell, H. M., Huse, G., and Cooke, P. W., *J. Chem. Soc.*, 153 (1943).

Simultaneous Sulphonation and Nitration in an Aromatic Nucleus

From the literature[1,2], when β-naphthylamine is nitrated by either: (1) the addition of potassium nitrate to a cooled solution of β-naphthylamine in concentrated sulphuric acid; or (2) the addition of β-naphthylamine nitrate to concentrated sulphuric acid, the products are 5-nitro and 8-nitro 2-naphthylamine.

If, however, β-naphthylamine is nitrated by the addition of a mixture of nitric and sulphuric acids to a solution of the amine in sulphuric acid at − 25°, or by the addition of β-naphthylamine sulphate to a mixture of nitric and sulphuric acids, the product is a mixture of two isomeric nitro aminonaphthalene sulphonic acids in the approximate ratio of 70 : 30, the main product being 1-nitro 2-aminonaphthalene 6-sulphonic acid. (The structure of the other isomer is not yet known.)

This reaction is peculiar in four respects: (*a*) it is the first case known to us of simultaneous sulphonation and nitration in an aromatic nucleus; (*b*) the main product is the result of *ortho–para* direction; (*c*) a remarkable difference in reaction mechanism is produced by comparatively small changes in experimental technique; (*d*) this anomalous behaviour is not shown by α-naphthylamine.

Details of this work will be published elsewhere.

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[2] Friedlander and Szymanski, *Ber.* **25**, 2076 (1892).

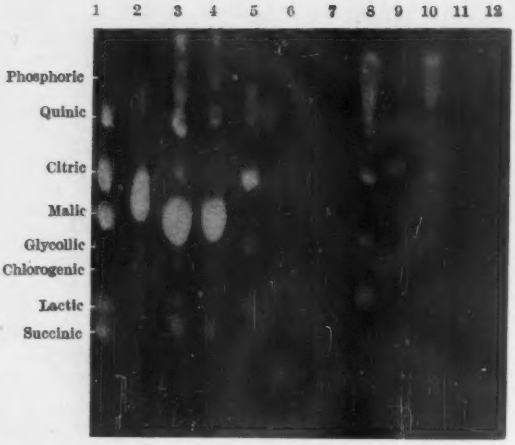
Degradation of Sugars on Ion-Exchange Columns of 'Amberlite IRA 400 (OH′)'

It has recently been suggested by Roseman *et al.*[1] that columns of 'Amberlite IRA 400 (OH′)' might be used for the separation of certain reducing and non-reducing carbohydrates. Our own experience with this resin suggests that very carefully controlled conditions would be necessary if reliable quantitative results are to be obtained. During an investigation of the non-volatile organic acid components of apple juice and cider, it has been found that sugars are extensively degraded by 'Amberlite IRA 400' used in the OH′ form, organic acids being the main products of degradation.

Paper chromatography was used for the separation of the acids following the technique of Lugg and Overell[2]. Interfering cations, sugars and other non-acidic materials were removed by the use of ion-exchange resins, 50-ml. samples of juice or cider being given the following treatments: (i) cation removal on 'Amberlite IR 120', (ii) anion removal on 'Amberlite IRA 400' and elution with *N* ammonium carbonate, (iii) removal of excess ammonium carbonate by evaporation on the water-bath, and (iv) removal of remaining ammonium ions by treatment with 'Amberlite IR 120'. 10-gm. quantities of resin retained in glass tubes of 0·8 cm. diameter were used throughout with a flow-rate of 1 ml./min.

Initially, the 'IRA 400' resin was used in the OH′ form, and it was found that a number of acid spots were apparent on the chromatograms of treated samples which were not found on those of samples before treatment or after stage (i) in the above procedure (compare chromatograms 2 and 3). Malic, quinic[3], chlorogenic[4] and phosphoric acids were identified as present in the juices; ciders contained succinic acid in addition. After ion-exchange treatment, chromatograms revealed five additional spots, two being identified as due to lactic and glycollic acids. Titration of samples after stages (i) and (iv) showed that the anion-exchange treatment resulted in increases of acidity, the extent varying according to the time of contact with the resin. Increases, expressed as malic acid, ranged from 0·05 per cent (in 2 hr.) to 0·40 per cent (in 17 hr.). Solutions containing a mixture of pure acids, when subjected to the above treatments, showed no change in acidity and the chromatograms showed no additional spots.

An average cider-apple juice contains sugars in the proportions fructose 10, sucrose 2 and glucose 1·5 per cent[5]. A neutral solution of sugars of this composition was passed through a column of 'IRA 400 (OH′)', the column washed thoroughly with distilled water and



Chromatograms developed in benzyl alcohol (3 vol.), tert. butyl alcohol (1 vol.), *iso* propyl alcohol (1 vol.), water (1 vol.) and formic acid 2 per cent (see ref. 8) and run at laboratory temperature. Papers sprayed with 0·08 per cent bromo cresol green in 95 per cent aq. ethanol.

1, Standard mixture of malic, quinic, succinic, lactic and citric acids; 2, untreated cider (S.G. 1010); 3, cider–acid extract using 'IRA 400 (OH′)'; 4, cider–acid extract using 'IRA 400 (CO_3″)'; 5, sugar solution (fructose, glucose and sucrose) after 'IRA 400 (OH′)' treatment; 6, sugar solution (fructose, glucose and sucrose) after 'IRA 400 (CO_3″)' treatment; 7, untreated fructose solution; 8, fructose solution after 'IRA 400 (OH′)' treatment; 9, untreated glucose solution; 10, glucose solution after 'IRA 400 (OH′)' treatment; 11, untreated sucrose solution; 12, sucrose solution after 'IRA 400 (OH′)' treatment

left overnight (17 hr.) before elution. An increase in acidity of 0·76 per cent was recorded, and the chromatogram showed that this increase was represented by the additional acid spots previously found in treated juices (chromatogram 5).

To determine the differential effect of the treatment on these three sugars, corresponding concentrations of each sugar were submitted separately to the resin treatment, the columns being left overnight before elution. The results are summarized in the accompanying table, sugars being estimated by the method of Somogyi[6].

From the table it can be seen that (1) there is no retention of any of the three sugars by 'Amberlite IR 120', (2) all three sugars are retained by 'IRA 400 (OH′)', (3) there is considerable degradation of fructose and glucose with the production of organic acids, (4) sucrose, a non-reducing sugar, is relatively little attacked by the resin, (5) sugars which have not been degraded can be removed from the column by elution with *N* ammonium carbonate. Chromatograms 7–8, 9–10 and 11–12 show the acids produced by degradation of the sugars.

	Weight of sugar (gm.)		
	Fructose	Sucrose	Glucose
(*a*) Entering 'IRA 400 (OH′)' column (50 ml. of solution)	4·04	0·85	0·61
(*b*) Present in effluent and water washings	2·8	0·005	nil
(*c*) Retained on 'IRA 400 (OH′)'	1·24	0·845	0·61
(*d*) Eluted by ammonium carbonate	0·53	0·80	0·32
(*e*) Present after 'IR 120' treatment (stage iv)	0·52	0·80	0·32
(*f*) Percentage of retained sugar (*c*) degraded in 17 hr.	57·3	0·05	47·6
(*g*) Acidity of final solution (50 ml.) as per cent malic	1·055	0·08	0·60

By using 'Amberlite IRA 400' resin in the CO_3″ form, as described by Bryant and Overell[7], it is possible to obtain practically sugar-free extracts of apple juice or cider showing no increases in acidity (chromatogram 4). Very little sugar is retained by the resin and there is no degradation even after a considerable period of contact (chromatogram 6).

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[1] Roseman, S., Abeles, R. H., and Dorfman, A., *Arch. Biochem.*, **36** (1), 232 (1952).
[2] Lugg, W. H., and Overell, B. T., *Aust. J. Sci. Res.*, A, **1**, 98 (1948).
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Filter-Paper Disk Chromatography

As a corollary to our comparative studies of the amino-acid metabolism of bacteria[1], it was necessary to develop a simple chromatographic technique suitable for routine use in the laboratory. Such a technique using filter-paper disks was developed and fully described[2]. Recent publications in *Nature*[3,4] and elsewhere[5] describing almost identical methods would suggest that our publication has escaped notice.

Our experience with paper disk chromatography in the past three years shows that, although the method is admirable for the separation of two or three substances, it is not a satisfactory substitute for large-scale paper chromatography in the separation of more complex mixtures such as protein hydrolysates.

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[1] Proom, H., and Woiwod, A. J., *J. Gen. Microbiol.*, **3**, 319 (1949).
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Paper Partition Chromatography of Natural Œstrogens

The paper chromatography of steroids, for example, cortical steroids, has already been investigated by Zaffaroni *et al.*[1] and by Bush[2]. Although the separation on paper of the natural œstrogens free or in compounds has already been investigated by Bush[3], Heftmann[4], Nyc *et al.*[5] and Boscott[6], a satisfactory separation of the three natural steroids on non-treated paper has, to our knowledge, not yet

been published. The method described below gives excellent results. It has been especially devised for separating and purifying the small amounts of œstrogens normally present in biological fluids.

The detection of quantities of œstrogens weighing about 1–5 μgm. on paper chromatograms is very successful after grinding a solution of 10 per cent antimony chloride in chloroform and heating it for 5 min. at 90–100° C. Spots of different colours are obtained with the three steroids: brown for œstrone, yellow for œstradiol and pink for œstriol. The limit of sensitivity is about a microgram. Examination under ultra-violet light increases the sensitivity of detection for œstradiol (0·2 μgm.) and œstriol (0·5 μgm.). This reaction is generally satisfactory. The spotting of œstrogens on paper can also be realized after treatment with Folin's, Pauly's and other diazo-reagents, and after drying and subjection to ammoniacal vapours. However, these diazo reactions are not so useful in practice.

One solvent—water—and the ascending method was first tried for the separation of the three phenolic steroids on paper. Because of their different dissociation constants, some alkaline solutions give different R_F values for the three hormones. With $N/20$ sodium hydroxide, for example, the results obtained are 0·04–0·21 and 0·5 respectively for œstrone, œstradiol and œstriol. Organic bases also give good results (15 per cent pyridine). However, in the light of our experiments, we consider that the utilization of aqueous solvents for clear separations is not advisable when steroids exceed 20–30 μgm., because of the streaky movements. Furthermore, when mixed with biological extracts, œstrogens do not always show the same R_F values as in pure solutions. In fact, the separation of œstrone from œstriol was the only one we could achieve, this being effected with $N/20$ sodium hydroxide or 33 per cent methanol.

A very satisfactory separation of the three natural œstrogens on paper can be obtained with the use of non-miscible liquids. Our method involved the use of glass cylinders (15 cm. in diameter and 40–50 cm. long) closed by means of two glass plates, and Whatman No. 1 filter paper. The descending method is normally employed. Saturation of the paper is first completed with $N/2$ ammonium hydroxide lying at the bottom of the cylinder. The most satisfactory mobile fluid found was the organic phase of a mixture of 1 part chloroform, 9 parts benzol and 1 part N ammonium hydroxide. This mobile phase is introduced into the cylinder without desaturation of the atmosphere. A movement of 30 cm. on the paper takes 2–3 hr. at room temperature. The positions of the spots are observed after drying the paper by spraying it with a solution of antimony chloride in chloroform and heating at 90–100°. The R_F values so obtained are, respectively, 0·89, 0·78 and 0·02 for œstrone, œstradiol and œstriol.

A similar separation is also obtainable with the same mobile phase, and methanol – water (1 : 2) being utilized for saturation of both the solvent and the atmosphere. The spots are, in this case, sharper, but the R_F values for œstradiol and œstrone are closer.

If, after separation on paper, the œstrogens are to be estimated, it is advisable to cut the paper into transverse strips corresponding to their theoretical R_F values. The elution of hormones is quantitative when utilizing the movement of a mixture of chloroform – acetone (1 : 1). The estimation may then be effected on the solutions by one of the known methods, especially fluorometry or polarography after nitration[7].

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Colour Reactions on Paper Chromatograms by a Dipping Technique

In a recent communication by Hulme and Arthington[1], writing of the isatin test for proline, they state that "it is surprising that this useful test has not been more widely used". This prompts a report of further advantages of this reagent and a description of a general technique which has been in use in this laboratory for some months.

In all experiments, 5 μl. of solution containing 0·01 M pure amino-acid or a synthetic mixture of twenty amino-acids all in the same concentration was used. Normal and pathological urine was also tested. One- and two-dimensional chromatograms were prepared in phenol/ammonia or butanol/acetic acid on papers 10 in. square, mounted in Datta frames[2]. After thorough removal of the solvent in a cold-air draught, the papers were drawn through a 0·2 per cent solution of recrystallized isatin in acetone contained in a shallow 'Pyrex' dish. As soon as the acetone had evaporated from the paper, it was heated for 2 min. at 105° C. or for 15 min. at 65° C., when proline and hydroxyproline produced the usual blue colour. In addition, cystine and often tyrosine appear blue; aspartic and glutamic acids, initially pink, assume a blue tinge; tryptophane appears reserved (as stated by Hulme and Arthington); and many other amino-acids, especially glycine, appear deep pink, although these pinks tend to fade. The comparison of this method with those of Hulme and Arthington and of Acher, Fromageot and Jutisz[3] is very favourable both with respect to depth and stability of colour and the number of amino-acids located.

Many substituted isatins, kindly supplied by Dr. S. J. Holt, have been tested. The N-methyl-, 6-Cl-, 7-Cl-, 5-methyl- and 5 : 7-dimethyl-isatins all give colours similar to isatin (but none of these justifies the replacement of isatin). The 6 : 7-dimethoxy, 4-Cl-, 7-COOH- and N-acetyl-isatins, 4 : 5-benzisatin and 5 : 5′-di-isatyl are negative.

The advantages of this dipping technique are that the amino-acids are insoluble in acetone and therefore do not spread, the paper dries in 1–2 min., there is no offensive smell (compare butanol or solvents containing 1 per cent collidine or pyridine) and the colours are generally deeper. The method is economical and the use of an expensive spray gun or tiresome and fragile handspray is eliminated.

Ninhydrin, as 0·2 per cent solution in acetone, is at least as satisfactory when applied by dipping as by the conventional spray technique. The colours develop after 1–2 min. at 105° C. or in 2–4 hr. in the cold. After this method had been in use for some time, it

was noted that Toennies[4] had recommended the same method.

Dipping in Ehrlich's reagent, *p*-dimethylaminobenzaldehyde, prepared fresh as a 1 per cent solution in a mixture of nine volumes of acetone to one volume of concentrated hydrochloric acid, gives the usual purple tryptophane colour within two minutes in the cold, deepening on standing. This compares favourably with the method of Dalgliesh[5], which takes two hours for tryptophane to appear. In general, the method is quicker for many of the amino-acids and amines listed by Dalgliesh.

Although this technique was developed for my own work on amino-acids, it is particularly valuable for student use, especially where speed in development (as for tryptophane) is a great advantage.

The technique has only been applied to amino-acids; but I believe that it would be equally valuable for many other classes of compound which are insoluble in acetone, ether or other volatile solvents. In addition, the method should be of value for spot-test reactions on paper, as these are often more sensitive than those carried out in the test-tube.

I wish to thank Dr. J. B. Jepson for his help and encouragement.

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Elastin and Elastase

In previous publications[1,2], we reported that extracts of animal pancreas made with fluids of different *p*H exhibit varying elastolytic activity (e.u./gm.) on account of the presence of elastase inhibitor, which in the pancreas is bound to elastase[3]. In crude neutral solution, the activation of elastase may be carried out by acidification, dialysis or precipitation with ammonium sulphate[1,2]. In all these procedures the elastase is being liberated from elastase-inhibitor. It has been pointed out by us that two types of elastase-inhibitor exist, namely, one in the pancreas and another in the blood serum[4]. Whereas that from the pancreas dialyses in 24–32 hr. and can be demonstrated in the dialysate, that from the serum cannot be dialysed.

We determined the elastase content of the pancreas of healthy young men who had died suddenly in consequence of accidents and compared the value obtained with the elastolytic activity found in the pancreas of men who had died of various diseases or had had arteriosclerosis[4]. Extracts were prepared from each human pancreas using the following methods: (1) fresh pancreas extracted with a double volume of *N*/10 acetate buffer of *p*H 4·7; (2) same as (1), with subsequent dialysation for 24 hr.; (3) extract of degreased pancreas powder prepared as (1) but with a five-fold volume of buffer; (4) same as (3), with subsequent dialysation for 24 hr.

We found that the pancreas of young healthy individuals (group 1, 10 cases) contained 208 ± 56 e.u./gm. The pancreas of those who had died of various diseases without arteriosclerosis (group 2, 14 cases) contained 155 ± 49 e.u./gm., whereas the pancreas of men who had had arteriosclerosis (group 3, 36 cases) yielded 9 ± 6·5 e.u./gm. Comparing the values of either group 1 or group 2 with group 3, the differences are significant. In 54 per cent of the cases of group 3, elastase could not be detected in the pancreas at all. Hall, Reed and Tunbridge[5] were not able to obtain elastase from human pancreas. This can be explained only by supposing that they disregarded the elastase inhibitor of the pancreas, the presence of which makes it impossible to demonstrate elastase without activation in sodium chloride or water extracts. Another possibility would be that they examined only human pancreas which contained no elastase. In the pancreas of men above the age of forty elastase is often lacking. Contrary to the finding of Hall, Reed and Tunbridge, however, we find that the pancreas of healthy men contains elastase, as has already been reported in our first publication[6].

Banga and Schuler[7] found that, following the action of elastase upon elastin, carbohydrate is liberated. This is in accordance with the finding of Hall, Reed and Tunbridge. The only difference is in the quantity of carbohydrate found. According to our results, as a consequence of elastolysis 10–12 per cent of carbohydrate is liberated from the elastin of Stein and Miller as well as from the elastins of both Gross and Banga. Hall, Reed and Tunbridge obtained from the aorta 2 per cent polysaccharide only. By the orcin method of Rimington[8] only a small part of the carbohydrate can be estimated, whereas the whole quantity can be determined by titration with hypoiodide or by the method of Hagedorn–Jensen. The elastin dissolved with elastase reduces ferric to ferrous iron in the cold and decolorizes dichlorophenolindophenol when heated. Molisch and Seliwanoff tests are negative. The carbohydrate liberated during dissolution of elastin resembles, in its reducing properties, glucosamine, since it cannot be estimated by the orcin method of Rimington and it does not give either the Molisch or Seliwanoff tests.

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Effect of Acetoacetate on Glycogen Synthesis and Glucose Utilization in the Isolated Rat Diaphragm

The effect of ketone bodies on carbohydrate metabolism is still obscure, and several theories have been proposed to explain their action[1–3]. Nagler[4] incubated surviving rat diaphragm in phosphate buffer medium containing glucose (200 mgm. per cent), glucose and insulin (0·05 unit per 1·0 ml.), glucose, insulin and acetoacetate (50 mgm. per cent). No effect of acetoacetate on glycogen synthesis was observed. Parnes and Wertheimer[5] reported that

acetoacetate depressed glycogen synthesis in the rat diaphragm, thus differing from other metabolites.

In the present experiments, we have extended the studies of Nagler and of Parnes and Wertheimer. Diaphragms of rats fasted for one day were incubated in phosphate buffer solution containing 50–100 mgm. per cent glucose. The addition of 100 mgm. per cent acetoacetate to the medium decreased glycogen synthesis and increased glucose utilization. These effects were highly significant when the medium contained 50 mgm. per cent glucose, and also significant in the presence of 100 mgm. per cent. Other products such as acetate, pyruvate and acetone were without effect.

The specific action of acetoacetate was influenced by the proportions of glucose to acetoacetate as shown in Table 1. An increase of the glucose concentration prevented the acetoacetate effect.

Table 1. Effect of Varying Glucose Concentrations in the Presence of Acetoacetate on Glycogen Synthesis and Glucose Utilization

Diaphragms were incubated at 37° C. for 2½ hr. Glycogen synthesis and glucose utilization expressed as mgm. glucose per 100 mgm. wet tissue

No. of experiments	Medium containing		Glycogen synthesis (mgm./100 mgm.)	Glucose utilization (mgm./100 mgm.)
	glucose (mgm. per cent)	aceto-acetate (mgm. per cent)		
7	50	—	0·098±0·020	0·30±0·03
7	50	100	−0·007±0·008	0·44±0·04
12	100	—	0·143±0·014	0·48±0·05
12	100	100	0·042±0·007	0·63±0·07
5	200	—	0·184±0·039	0·75±0·03
5	200	100	0·172±0·014	0·78±0·04

The results shown in Table 1 explain the results obtained by Nagler[4].

Addition of insulin to a medium containing glucose increased the glycogen synthesis and glucose utilization by the rat diaphragm, as was first described by Gemmill[6]. Addition of insulin to a medium containing glucose and acetoacetate caused a smaller increase, as illustrated in Table 2.

Table 2. Effect of Acetoacetate in Glucose and Glucose + Insulin Media

Diaphragms incubated at 37° C. for 2½ hr. Glucose concentration, 100 mgm. per cent; acetoacetate concentration, 100 mgm. per cent; insulin, 0·1 unit per 1·0 ml. Glycogen synthesis and glucose utilization expressed as mgm. glucose per 100 mgm. wet tissue

No. of experiments	Samples incubated	Difference in	
		Glycogen synthesis (mgm./100 mgm.)	Glucose utilization (mgm./100 mgm.)
7	Glucose with and without insulin	+0·123±0·013	+0·51±0·010
9	Glucose and aceto-acetate with and without insulin	+0·073±0·013	+0·41±0·006

Results similar to those shown in Table 1 were observed in diaphragms of mildly diabetic rats (blood-sugar level, 100–300 mgm. per cent); but acetoacetate had no effect on the diaphragms of severely diabetic rats (blood-glucose level, 400 mgm. per cent or higher, acetonuria), of rats in diabetic coma, and of rats fasted for five to seven days. The latter group of fasted rats lost 35–40 per cent of their initial weight and were in poor condition.

A single intraperitoneal injection of 100 mgm. acetoacetate per 100 gm. body-weight was given to normal rats. Acetate or saline was administered to controls. 1–3 hr. after injection of these compounds, the animals were bled and their diaphragms incubated in a phosphate buffer medium containing 100 mgm. per cent glucose.

The injected acetoacetate depressed glycogen synthesis in the incubated diaphragms. Acetate and saline were without effect. Acetoacetate[2] as well as acetate caused hypoglycæmia and increased alkalosis. Acetoacetate increased acetone bodies in the blood to 10 mgm. per cent (controls, 4·5 mgm. per cent) 2 hr. after injection. These *in vivo* results were thus similar to those obtained *in vitro* by addition of acetoacetate to the incubating medium. They were due solely to the injection of acetoacetate, and did not appear after acetate or saline administration.

It is concluded that acetoacetate has both an *in vitro* and an *in vivo* influence on carbohydrate metabolism in muscle. The depression of glycogen synthesis by acetoacetate is demonstrable also in the presence of insulin.

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Effect of L-Glutamic Acid Analogues on the Enzymatic Formation of Hydroxamic Acid

Aqueous extracts of acetone-dried sheep brain form hydroxamic acid from L-glutamic acid and hydroxylamine in the presence of adenosine triphosphate[1]. It was found that this reaction is inhibited by DL-N-(γ-glutamyl)-ethanolamine. Molar ratios of DL-N-(γ-glutamyl)-ethanolamine to L-glutamic acid varying from 2 : 1 to 10 : 1 gave inhibitions of 10–50 per cent. On the other hand, DL-α-methylglutamic acid not only did not inhibit the reaction between L-glutamic acid and hydroxylamine, but could be substituted for glutamic acid in this reaction, apparently with the formation of α-methylglutamohydroxamic acid.

The sheep brain transferase system[2] which forms glutamohydroxamic acid from hydroxylamine and L-glutamine is not affected by DL-N-(γ-glutamyl)-ethanolamine but is inhibited by DL-α-methylglutamic acid as well as by D-glutamic acid. Molar ratios of DL-α-methylglutamic acid to L-glutamine varying from 2 : 1 to 20 : 1 gave inhibitions of 25–70 per cent; whereas molar ratios of D-glutamic acid to L-glutamine varying from 1·25 : 1 to 5 : 1 gave inhibitions of 25–45 per cent.

Both the synthesizing and the transferring reaction were measured by estimation of the hydroxamic acid formed. The synthesizing reaction was also measured by estimating the inorganic phosphate liberated from adenosine triphosphate.

When in the synthesizing reaction between DL-α-methylglutamic acid and hydroxylamine the latter was replaced by ammonia, free phosphate was also liberated from adenosine triphosphate. Evidence indicating the formation of α-methylglutamine was obtained by use of paper chromatography.

An inhibition of the synthesis of glutamohydroxamic acid from glutamic acid and hydroxylamine by DL-N-(γ-glutamyl)-ethanolamine was also obtained with dialysed extracts of acetone-dried pigeon livers prepared according to Speck[3]. These extracts also formed a hydroxamic acid from hydroxylamine and DL-α-methylglutamic acid.

An inhibition of both the synthesizing system and the transferase system by methionine sulphoximine has recently been described by Pace and McDermott[4].

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Non-Effect of Hyaluronidase on the Spread of Œstrone

Since it is known that hyaluronidase increases the spread of certain substances in the skin of mammals by increasing the permeability of the dermis[1], it appeared possible that this enzyme might affect the spread of œstrone where this can be shown to be localized in the dermis.

The administration of œstrone to Brown Leghorn capons changes the colour of developing feathers from black to rust. If a small amount of œstrone in 60 per cent alcohol is injected intradermally, such an effect may continue for some days and is mainly produced in the vicinity of the injection[2], although feathers developing in other parts of the body may also react. It may be supposed, therefore, that while some of the hormone is carried away, some remains available near the site of the injection and is responsible for a localized reaction.

It is possible that such results are explained by the fact that the œstrone was injected in alcohol, since it is now known that, although alcohol penetrates the dermal barrier freely at first, the area of spread is afterwards limited by skin coagulation which follows[3]. Nevertheless, it was thought worth while to see if this partial localization of the effect of injected œstrone was affected by hyaluronidase.

Intradermal injections of œstrone with and without hyaluronidase were made in plucked patches where feathers were regenerating on the breasts of Brown Leghorn capons. These injections also contained hæmoglobin prepared from fresh sheep's blood, since the degree of spread of hæmoglobin is an accepted method of assay of hyaluronidase. Since œstrone is only very sparingly soluble in water and hæmoglobin coagulates in strong alcohol, it was found convenient to use a mixture of hæmoglobin and œstrone in 40 per cent alcohol. Doses of 0·1 ml. were given, and the concentrations were so arranged that each dose contained 0·05 mgm. of œstrone or, in a few cases, half this. Similar mixtures, in similar doses, were used in the experimental series, but with the addition of hyaluronidase equal to the œstrone in weight. In each experiment each capon received two injections at intervals of a week. After three months, the feathers were plucked and filed.

When hyaluronidase was included in the injection, its presence was shown by an immediately increased rate of spread of hæmoglobin. The area of subsequent spread of hæmoglobin was recorded on plots of the feather patches approximately six hours after the injection. Fifty-four injections were made, half of which contained hyaluronidase: of these, seventeen gave an increased spread in six hours; in seven cases this spread was not markedly increased, and in three it was reduced as compared with the controls.

On the other hand, the inclusion of the enzyme was not associated with any significant change in the following measurements made on the plucked feathers: (1) the area of the largest rust-coloured mark on any feather in the patch; (2) the length of the longest rachis mark; (3) the average area of mark per affected feather; (4) the average length of rachis mark per affected feather; (5) the total affected area of feather; (6) the percentage of surviving feathers affected. These results were obtained from experiments on six birds, in which it was possible to make fifteen strict comparisons between marks caused by œstrone with and without hyaluronidase.

These results seem to indicate that, although the rate of spread of the hæmoglobin is affected, the spread of œstrone is not affected by hyaluronidase. It is, however, possible that the interstitial pressure did not remain sufficiently high for the hyaluronidase to affect the ultimate spread of the injection. It has been shown that, in an intradermal injection, hyaluronidase only acts if there is local increase of interstitial pressure produced by the injection. As the injected fluid spreads, the bleb pressure diminishes until it is equal to the normal interstitial pressure of the skin. At this point excess hyaluronidase no longer affects spreading[4]. In our experiments we found that the rate of spread of hæmoglobin was initially increased, but we do not know whether the ultimate area of spread was affected, as the indicator became too indistinct to be measured.

In further work to test whether hyaluronidase affected a non-local reaction, spayed female mice were implanted with a crystal of œstrone in the neck and half of them received in addition dry hyaluronidase. The hyaluronidase is probably rapidly dissolved in the body fluids. By this means any complications which might have arisen from the use of any solvent or vehicle were eliminated[5], although the possible different states of the crystals used may be a ground for criticism of this method. The results seemed to indicate that the enzyme did not affect the rate of uptake of œstrone by the animal as measured by the time of onset or by the rate of thickening of the vaginal epithelium. In another series, hyaluronidase dissolved in water was repeatedly injected subcutaneously following implantation of œstrone crystals as above. Once more, no significant effect of the enzyme could be found.

Although this work is not regarded as complete or conclusive, it appears that in the mouse the uptake of œstrone is controlled by some mechanism less easily disturbed by hyaluronidase than is, for example, the mechanism which controls the uptake of such substances as are used medically in hypodermoclysis[6].

This work was done during the tenure by one of us (M. E. B.) of a research award of University College, Hull.

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Seasonal Fluctuations in the Degree of Hatching from Cysts of the Potato Root Eelworm

THE rate of hatching of larvæ from cysts of the potato root eelworm *H. rostochiensis* Woll. during *in vitro* hatching tests has been found by many workers to show seasonal fluctuations, a high level of larval emergence during the summer months declining to a negligible hatch during the winter.

After a series of experiments to measure this fluctuation quantitatively, Lownsbery concludes[1] that the phenomenon is inherent in the physiology of the worm and is not correlated with any seasonal difference in the leachings used. He agrees with Reinmuth[2] that exposure to winter conditions is not necessary for the induction of the dormant period. His attempts to break the dormancy by temperature and humidity control were unsuccessful. The phenomenon of winter dormancy was also demonstrated by Triffitt[3].

We have been conducting *in vitro* hatching tests for a number of years, and now wish to record that for the past three years we have not found any apparent diminution in the 'hatchability' of the cysts during the winter months. Cysts floated from soil collected during the spring and summer months are rolled from the debris and stored in small bottles or large tubes in a dark cupboard at room temperature. The corks are notched at one side to allow free air circulation. No attempt is made to maintain a uniform temperature; the normal fluctuations in room temperature appear to have no harmful effect provided the temperature does not fall below about 15° C. The root diffusate used in all the hatching tests is collected during the summer, pooled, mixed and then stored at about 3°–4° C. When setting up a hatching test, the cysts are weighed into batches on a micro-balance[4] and soaked in tap water for about fourteen days. Afterwards, the water is removed and root diffusate added, when normal hatching occurs.

Our experience indicates that *Heterodera* cysts are not essentially subject to a winter dormancy. The low hatches during the winter months encountered by other workers probably result from the influence of external environment, possibly soil conditions at the time of cyst extraction. This view is supported by the fact that cysts washed from soil taken from fields in late autumn or winter show an apparent dormancy, whereas cysts recovered from the above soil during the summer and stored under the same conditions do not. The apparent dormancy encountered cannot be of so fundamental a nature as suggested by Lownsbery[1], since cysts recovered from soil and stored under the conditions described above are capable of hatching at the normal rate throughout the winter months.

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Experimental Induction of Male Cones in *Pinus sylvestris*

IT is well known that seedling trees of *Pinus sylvestris*, in common with those of many other woody species, pass through a juvenile period, during which no reproductive organs are formed. The first female cones appear at the age of about seven years, while male cones are not usually formed until several years later. These male cones generally appear first on the lower, older branches.

In 1950, I observed that certain trees of about twelve years of age growing in plantation at Oxshott Common, Surrey, bore numerous female cones; but none of the trees showed branches which had passed to the male condition. Closer inspection revealed a few isolated male shoots, however, and in every case these were borne on vegetative shoots of which the terminal bud had failed to develop in the previous season, due to attack by an insect (the identity of which has not yet been determined). As a result of this destruction of the terminal bud, the uppermost 'dwarf shoots' (bearing paired needles) had been stimulated to produce a resting bud, and it was in such buds that male cones had developed. I have since observed similar examples on several occasions in various localities.

In order to test whether experimental removal of the terminal buds would have the same effect, a considerable number of shoots on the lower branches of ten of the trees in question were disbudded by hand in January 1951. One or two of the uppermost dwarf shoots on each treated shoot developed resting buds during the summer of 1951, and these unfolded in the spring of 1952. Inspection in May 1952 revealed that 242 out of a total 472 treated shoots (that is, 53 per cent) had developed male shoots, and these were the only ones present on the trees in question (apart from a few isolated male cones again found to be associated with insect-destruction of the normal terminal bud). In some branches, 100 per cent of the treated shoots had produced male shoots.

Thus, experimental disbudding may be used for hastening the production of male cones in young trees of *P. sylvestris* and might prove a valuable addition to the other techniques, such as bark ringing and strangulation, already used in forest tree breeding.

The results of the present experiments correspond in certain respects with the experimental induction of lateral flower buds in the Haden mango by removal of the terminal bud[1].

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FORTHCOMING EVENTS

Monday, January 5

BRITISH INSTITUTION OF RADIO ENGINEERS, LONDON SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Dr. G. A. Veszi: "The Modern Single Layer Selenium Photocell".

Tuesday, January 6

INSTITUTION OF ELECTRICAL ENGINEERS, joint meeting of the MEASUREMENTS and RADIO SECTIONS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. D. McMullan: "An Improved Scanning Electron Microscope for Opaque Specimens".

Wednesday, January 7

PHYSICAL SOCIETY, COLOUR GROUP (at the Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 3.30 p.m.—Scientific Papers.

Thursday, January 8

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 4.30 p.m.—Sir John Cockcroft, F.R.S.: "Nuclear Reactors and Applications"; at 6 p.m.—Symposium on "Nuclear Reactor Instrumentation".

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. A. E. Haarer: "The Behaviour of the Chief Jute-Substitute Plants".

Friday, January 9

BRITISH PHYCOLOGICAL SOCIETY (in the Hatton Lecture Theatre, Queen Mary College, Mile End Road, London, E.1), at 10.30 a.m.—Symposium on "Marine Algal Ecology"; Accounts of Recent Shore Surveys of (i) Fair Isle (Speakers: Dr. E. Conway, Dr. E. M. Burrows, Dr. S. M. Lodge and Mr. H. T. Powell), (ii) Anglesey (Speaker: Dr. J. R. Lewis); at 4 p.m.—First Annual General Meeting.

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Scientific Papers.

INSTITUTE OF ECONOMIC ENGINEERING (at Cowdray Hall, Henrietta Place, Cavendish Square, London, W.1), at 7 p.m.—Mr. R. M. Currie: "Work Study as a Means of Improving Industrial Efficiency".

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 7 p.m.—Prof. E. R. H. Jones, F.R.S.: "New Routes to Cortisone".

Saturday, January 10

BRITISH PSYCHOLOGICAL SOCIETY (in the Sharpe Theatre, Department of Psychology, University College, Gower Street, London, W.C.1), at 2.30 p.m.—Dr. Leonard C. T. Jones: "Frustration and Unreasonable Behaviour"; Miss S. K. Madan: "An Interviewing Technique involving Projection from the Tactile Kinæsthetic Modalities".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT (Grade B) IN CHEMISTRY (with good honours degree) at the Brighton Technical College—The Education Officer, 54 Old Steine, Brighton 1 (January 10).

NUTRITION OFFICER (with an honours degree in biochemistry or physiology) to take part in work that will include the determination of the biological value of proteins, the study of calcium and phosphorus metabolism using radioactive tracers, vitamin D assays, and general nutritional experiments with rats—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 52/14 (January 10).

DEMONSTRATOR IN CHEMICAL PATHOLOGY—The Registrar, The University, Leeds 2 (January 12).

ENGINEERING and PHYSICS GRADUATES to join a group working on non-linear servomechanisms and controls—The Secretary, Engineering Laboratory, Trumpington Street, Cambridge (January 15).

PRINCIPAL—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (January 16).

BIOCHEMIST at the Institute of Medical and Veterinary Science, Adelaide, to be responsible for all the routine work of the biochemistry division of the Institute, and also to have charge of the clinical biochemistry department of the Royal Adelaide Hospital—The Agent-General for South Australia, South Australia House, Marble Arch, London, W.1 (January 17).

PRINCIPAL SCIENTIFIC OFFICERS and SENIOR SCIENTIFIC OFFICERS for research and development work associated with the testing and performance of guided missiles, SENIOR EXPERIMENTAL OFFICERS and EXPERIMENTAL OFFICERS (Grade 3) to be responsible for the detailed inspection of the work of sections engaged in the experimental or engineering aspects of guided weapons research and development, at the Long Range Weapons Establishment, Salisbury, Australia—The Senior Representative, Department of Supply, Canberra House, 87 Jermyn Street, London, S.W.1 (January 17).

LECTURER or ASSISTANT LECTURER IN ECONOMIC STATISTICS—The Registrar, The University, Manchester 13 (January 20).

SCIENTIST, Grade I (physical chemist or chemical engineer, with not less than a second-class honours degree) to supervise the design and operation of pilot plants—The National Coal Board, Central Research Establishment, Stoke Orchard, Cheltenham, endorsed TT/577 (January 26).

READERSHIP IN HUMAN PHYSIOLOGY at St. Mary's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 9).

I.C.I. RESEARCH FELLOWSHIPS IN PHYSICS, CHEMISTRY, ENGINEERING, METALLURGY, PHARMACOLOGY, or any related subject—The Registrar, The University, Liverpool (March 1).

BEIT MEMORIAL FELLOWSHIPS FOR MEDICAL RESEARCH—The Secretary, Beit Memorial Fellowships for Medical Research, Lister Institute, Chelsea Bridge Road, London, S.W.1 (April 14).

AGRICULTURAL OFFICER (with a degree in agriculture, and, preferably, training in pasture management and soil conservation), Bechuanaland Protectorate—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.63/76/01.

DEMONSTRATOR IN BOTANY—The Registrar, The University, Nottingham.

DEPUTY HEAD OF THE DEPARTMENT OF AIRCRAFT PROPULSION—The Registrar, College of Aeronautics, Cranfield, Bletchley, Bucks.

ELECTRICAL ENGINEER or PHYSICIST at the Royal Aircraft Establishment, Farnborough, to undertake experimental work on design of fuses for bombs and guided weapons—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.474/52A.

ENGINEER in the Ministry of Supply, London, for locating, assessing and developing capacity for pilot manufacture of electronic assemblies and components—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.500/52A.

RESEARCH PHYSICIST—The Director, M.R.C. Radiobiological Research Unit, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

SCIENTIFIC OFFICER, Grade I (a good degree in science, engineering or mathematics is essential) IN THE ENGINEERING LABORATORY at Derby—The Director of Research, Railway Executive, 222 Marylebone Road, London, N.W.1.

SENIOR SCIENTIFIC OFFICER or SCIENTIFIC OFFICER (with first- or second-class honours degree in inorganic or physical chemistry) at the Water Pollution Research Laboratory, Watford, for research on the rates, under different conditions, of reactions occurring in the polluted Thames estuary including reduction of sulphate and oxidation of sulphide—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London S.W.1, quoting F.697/52A.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Department of Scientific and Industrial Research. Report of the Forest Products Research Board with the Report of the Director of Forest Products Research for the Year 1951. Pp. vi+66+8 plates. (London: H.M. Stationery Office, 1952.) 3s. net. [1111

Department of Scientific and Industrial Research: Building Research Station. National Building Studies, Special Report No. 14: An Inquiry into Domestic Hot Water Supply in Great Britain. Part 2: The Use of Water Heating Appliances in Summer, and the Relation between the Usage of Hot Water and the Appliances Available. Pp. vii+78. (London: H.M. Stationery Office, 1952.) 3s. net. [1111

Other Countries

Nyasaland Protectorate. Annual Report of the Geological Survey Department for the Year 1951. Pp. 17+5 plates. (Zomba: Government Printer, 1952.) 4s. [1011

Centro Brasileiro de Pesquisas Fisicas. Notas de Fisica No. 4: A New Radioactive Method for Marking Mosquitoes. By Mario B. Aragão, Elisa Frota-Pessôa and Neusa Margem. Pp. 5. Notas de Fisica No. 5: Methods of Obtaining High Vacuum by Ionization; Construction of an 'Electronic Pump'. By Helmut Schwarz. Pp. 9. (Rio de Janeiro: Centro Brasileiro de Pesquisas Fisicas, 1952.) [1011

Proceedings of the American Philosophical Society. Vol. 96, No. 5: Some Unorthodoxies of Modern Science, and other Papers read at Meetings of the Society. Pp. 503–628. (Philadelphia: American Philosophical Society, 1952.) 1 dollar. [1011

What is Race?: Evidence from Scientists. By Diana Tead. Pp. 88. (Paris: Unesco; London: H.M. Stationery Office, 1952.) 250 francs; 1 dollar; 5s. net. [1011

Smithsonian Institution: Bureau of American Ethnology. Bulletin 150: The Modal Personality Structure of the Tuscarora Indians as revealed by the Rorschach Test. By Anthony F. C. Wallace. Pp. viii+120. (Washington, D.C.: Government Printing Office, 1952.) 60 cents. [1111

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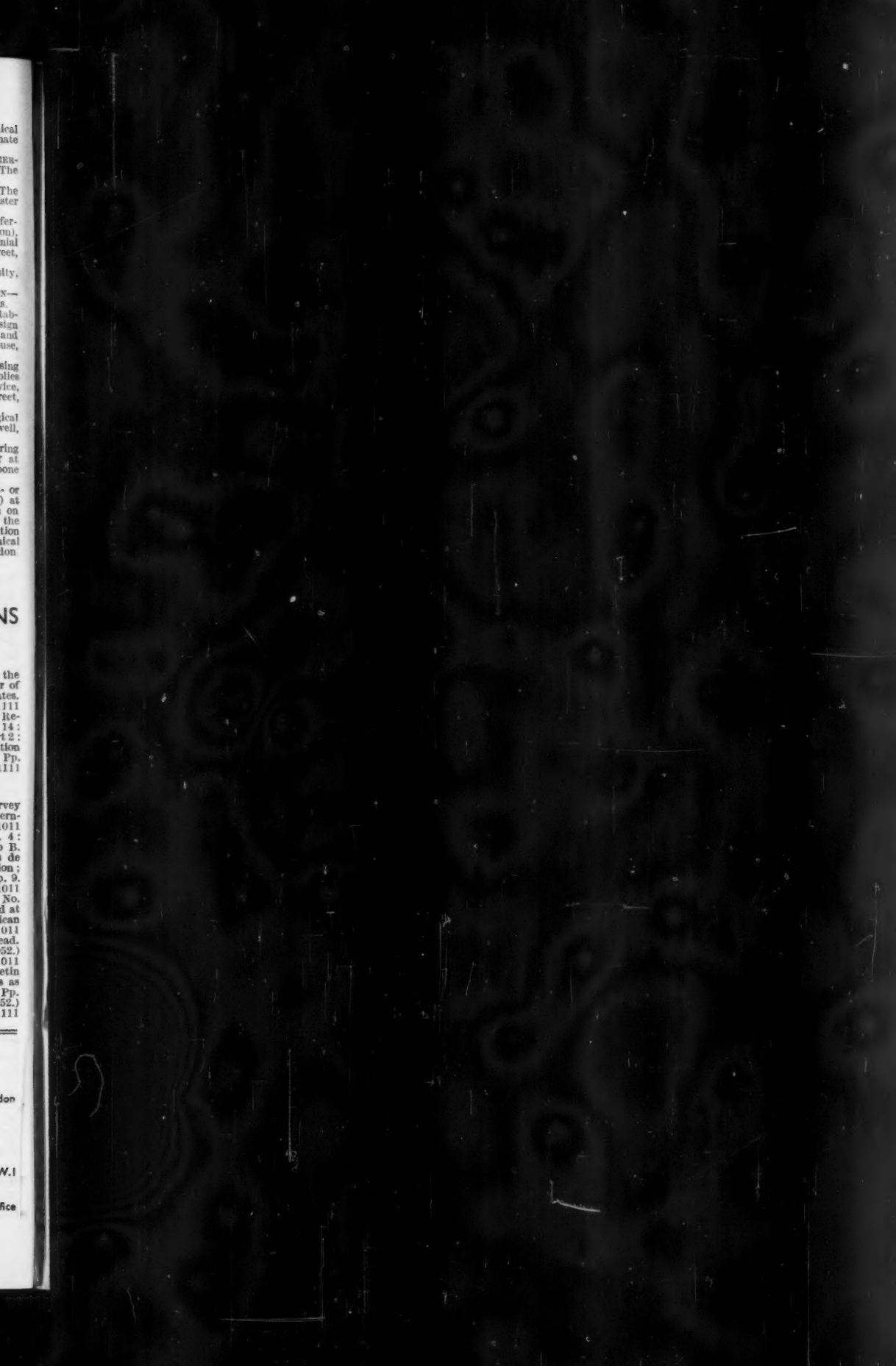
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